NATIONAL CANNERS ASSOCIATION

RESEARCH LABORATORY—Bulletin No. 21L.

W. D. BIGELOW, Director

Tomato Products

Pulp, Ketchup and Chili Sauce

BY

W. D. BIGELOW and A. E. STEVENSON

WASHINGTON, D. C.
AUGUST, 1923

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TOMATO PULP

INTRODUCTION

Tomato pulp is the fleshy portion of the tomato separated from skins, cores and seeds by means of a fine mesh screen and suitably concentrated by evaporation.

During recent years great improvements have been made in the manufacture of tomato pulp and in the quality and appearance of the product. The care exercised in the selection of the raw material and in all steps of the manufacture of tomato pulp has been greatly increased. This is equally true of pulp marketed in small cans to be used as soup stock in private homes and of the pulp sold in larger containers for the manufacture of soup and ketchup. The large buyers of pulp have determined the grade or quality which gives them the best results in the manufacture of other products and the degree of concentration which they can use most economically. It is now customary, therefore, for large sales of pulp to be made on specifications, and it is impracticable to comply with such specifications without carefully controlling the manufacture of the product. The raw material must be so selected and the manufacturing operations so controlled that the color and flavor of the finished product is conserved. This is discussed briefly on page 7.

If he desires to sell under specification, the manufacturer must comply with his contract with respect to specific gravity, and he cannot greatly exceed the specific gravity specified without substantial sacrifice in cost of manufacture. It is therefore economical to determine the specific gravity of the product as accurately as practicable (see p. 51) and also to adopt methods of manufacture that will control as closely as possible the specific gravity of the finished product.

Beginning on page 33, methods are given for the determination of specific gravity under various conditions of manufacture and sale, and on page 50 is given the method for the determination of specific gravity of the cyclone juice or partly concentrated pulp which this laboratory has suggested as an aid to determining the volume to which the product should be evaporated to secure the desired specific gravity. This method has been used by a number of pulp manufacturers and found to be relatively convenient and practicable. It might be

used to better advantage and to considerably greater profit if more help were employed—and some times more competent help—in determining specific gravity and controlling the point at which evaporation should stop.

The importance and economy of accuracy in the determination of specific gravity is not fully appreciated by all, though some of the larger manufacturers are now giving much attention to that subject. This matter is discussed on page 50.

There is included in the bulletin beginning on page 13 a detailed description of the Howard method for the microscopic examination of tomato products, and following that a detailed statement of the chemical and physical methods employed in this laboratory for their examination. Such methods are only of value to those trained in laboratory work. They are included here because the laboratory receives many requests for these methods from chemists employed by manufacturers of pulp. Men who are employed only for the tomato season find special need for such information.

Our correspondence brings many inquiries regarding the percentage of solids in pulp of different specific gravities, and also regarding the relative values of pulp of different specific gravities. In Table 10 (p. 59) there is given in parallel columns the specific gravities of pulp of different degrees of concentration and corresponding percentage of solids, and it is a simple matter to calculate the volume which the same pulp would make if concentrated to any other specific gravity. This calculation is explained on page 54— in discussing the point at which to stop evaporation to secure pulp of any desired specific gravity.

This bulletin supersedes Bulletins 3 and 7, and also contains material which has appeared in several trade-paper articles prepared in this laboratory. These articles are extensively quoted and some of them are printed almost in full. Dr. F. F. Fitzgerald was the coauthor of most of these publications and did much of the work on which they were based. He is therefore entitled to a substantial share of the credit for the material in this bulletin.

SANITARY CONTROL OF TOMATO PULP FACTORIES

The manufacture of tomato pulp requires careful supervision from beginning to end. The raw product must be carefully selected, and all possible steps should be taken to induce growers to discard rot-

ting tomatoes in the field and to expedite the movement of the raw product from field to factory. Tomatoes must be carefully washed and sorted. It is only practicable to accomplish the latter by means of some type of sorting belt. Sorters should not attempt to trim. Their full attention should be given to the tomatoes passing by them. The sorter may place the tomatoes requiring trimming in a separate receptacle in order that they may be carried to a table not provided with a moving belt and handled by special trimmers. Conveyors, receptacles and machines must be constructed and installed with a view to convenience in cleaning. Care must be taken to expedite the manufacture of the product in every way possible in order to give no opportunity for bacterial growth during the process of manufacture.

The brief comments given above are offered by way of reminder. This important subject is not further discussed because it has been adequately treated by Mr. B. J. Howard of the U. S. Bureau of Chemistry in bulletins which are readily available. These bulletins are designated as Bulletins 569 and 581, respectively, of the United States Department of Agriculture. They may be secured by requesting them of the Superintendent of Documents, Government Printing Office, this city, and enclosing five cents in coin for each copy desired. All manufacturers of tomato pulp will do well to study these bulletins and have them studied by their responsible employees.

QUALITY OF PRODUCT

There is a growing tendency to give increased attention to the quality of tomato pulp. The tomatoes should be ripe and well colored. Green tomatoes or tomatoes with green portions not only do not have the requisite amount of red coloring matter but they contain material which masks and dulls the color of fully ripe tomatoes. There is a difference of opinion among successful manufacturers of pulp regarding the relative color of pulp manufactured after hot or cold cycloning. Some maintain that a better color is obtained by cycloning hot. Others, apparently equally skilled and able to manufacture an equally good product, maintain the reverse. Much depends on the control of the cyclone—the setting of the paddles and the speed at which they are operated.

The evaporation should be as rapid as possible. The operation of the kettles in such a way that the pulp burns on the kettles or on the coils damages the flavor of the product and impairs its color. The pulp should be cooled promptly after processing, or if that is not

practicable should be stacked loosely so that the cans will have ample ventilation until they are entirely cooled.

Pulp packed in five-gallon cans is rarely processed. It should, however, be filled into the cans at a temperature of at least 180° F. It is best to give pulp in No. 10 and smaller size cans a short process in boiling water. With pulp filled at 180° F., ten or fifteen minutes is a sufficient cook. Pulp filled at lower temperatures or which is allowed to partially cool before processing requires a longer process.

In order to protect the color it is best to water cool No. 10 cans of pulp after processing. Pulp in cans of any size should not be stacked solid while it is still hot. The metal of the can has a bleaching action on the pulp and this is greatly increased if the pulp is stacked hot or stored in a hot warehouse. If stacked while excessively hot, stack-burning may occur with consequent darkening of the pulp.

As indicated above, there is a considerable difference of opinion among successful manufacturers of pulp regarding the details of manufacture necessary to secure the best results. It is probable that different conditions call for different methods of operation. At any rate, all successful manufacturers are agreed that the color of the pulp is an important index to its quality and greatly influences its commercial value. The flavor of pulp is also an important criterion and is considered by many buyers in forming an estimate of the value of pulp. A scorched taste or a flat flavor show that the manufacture of the pulp was not adequately controlled and impairs the commercial value of the product.

Color and flavor commonly go together. The same manufacturing methods which yield a product of high color are likely to give a product of superior flavor.

DISCARDING TOMATO JUICE

It was formerly customary, and is still the practice of some manufacturers of tomato pulp, to discard a portion of the juice of the tomatoes. Some manufacturers, especially in the preparation of pulp from tomato trimmings, allow the trimmings to pass over a colander and thus separate the free juice, which is discarded. Others allow the product of the cyclone to stand for a time in tanks and then discard the clear juice which settles in the bottom of the tanks. Both practices are wasteful and have generally been discontinued. Some still adhere to one or both, however, and it was thought best to make the matter the subject of study.

Some discard the juice because of the belief that it consists of nothing but water and is valueless. Some are of the impression that the juice separated from the trimming stock before straining takes on a brown color during evaporation which would interfere with the red color desired in the finished product, if allowed to go into the pulp. Some recognize the value of the juice, but believe that the expense of its evaporation would not be warranted by the increased quantity of pulp. Some have not measured the juice discarded and greatly underestimate its volume.

With the view of determining the approximate value of the material discarded in this manner, a batch of material, fresh from the cyclone, was divided into two portions, one of which was immediately concentrated to form a pulp, and the other was allowed to stand about 20 minutes when a clear liquor had separated at the bottom. This clear liquor was then removed and the remainder evaporated until the desired consistency was obtained.

Samples of the finished pulps, of the raw product from which each was prepared and of the clear liquor, separated from the second one, were preserved by sealing in cans and processing. These samples were numbered as follows:

702—Product from the trough under the second cyclone, or finisher.
703—Clear liquor, which separated at the bottom of the tank, after a portion of 702 was allowed to stand. This formed about one-fourth of the entire product of the tank.
704—Drained residue from 703.
705—Finished pulp obtained by concentrating 704.
706—Finished pulp obtained by concentrating 702.

These samples were examined with the results given below.

Table 1.—*Composition of Pulp and of the Liquor Separated from It*

Sample Number	Total Solids	Insoluble Solids	Ash	Sugar (as Invert)	Acid (as Citric)	Undetermined Organic Matter
	Per Cent	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
702	4.38	0.40	0.34	2.27	0.29	0.87
703	3.84	0.10	0.38	2.32	0.29	0.75
704	4.47	0.50	0.38	2.31	0.31	0.77
705	9.17	1.83	0.78	4.07	0.51	1.87
706	7.85	0.98	0.69	3.51	0.46	2.04

The two products (705 and 706) were evaporated under exactly

the same conditions and to what appeared to the operator to be the same consistency. After cooling, however, it was apparent that while the body of the two finished products was apparently equal, the consistency of No. 706 was superior to No. 705 in that the former was smooth and creamy, whereas the latter had a somewhat irregular, lumpy appearance. This difference was doubtless due to the greater content of soluble solids in No. 706. The color of the two samples was identical.

A mixture of one part of No. 703 and three parts of No. 704 when evaporated in the laboratory to the same consistency was identical in every way with No. 706.

From the composition as stated in Table 1 it is apparent that the flavor and food value of the clear juice, which is sometimes discarded (represented in No. 703), are practically identical with the unconcentrated pulp as it passes through the cyclone. In fact, the only difference between the two appears to be about one-half per cent of insoluble matter. When the product is allowed to separate, it seems probable that this insoluble material as it rises in the mass has a tendency to act like a filter and carry up with it a large proportion of the bacteria and moulds present.

The scale on which the work was done did not permit of sufficiently accurate measurement of the finished pulp to warrant the calculation of the loss in quantity caused by discarding the juice. From the composition of the pulps and of the raw material, however, it is apparent that this loss is practically proportional to the percentage of juice discarded.

It is apparent, therefore, that the evaporation of the material just as it passes through the finisher will yield a product of the same color, of better consistency, in considerably greater quantity, and at practically the same proportionate expense of concentration as the evaporation of the residue after discarding the juice in accordance with the custom mentioned above.

COMPOSITION OF TOMATO PULP [1]

Whole Tomato Pulp

The results obtained by the examination of 33 samples of whole tomato pulp are given in Table 2. The concentration of the samples

[1]This chapter is taken largely from an article by Bigelow and Fitzgerald, published in the Journal of Industrial and Engineering Chemistry, 1915, vol. 7, page 602.

varies from unconcentrated pulp as it runs from the cyclone to pulps of very heavy consistency. This table contains the data from which Tables 4 and 5 were calculated, although during the season a partial analysis was made of a large number of other samples, and the data secured therefrom were in all respects confirmatory of the relations calculated from Table 2.

In addition to the data obtained by the various determinations, Table 2 gives the relation between the results of the determinations for each individual sample. For instance, the ratio of pulp solids to filtrate solids (pulp solids divided by filtrate solids) varies in the different samples from 1.091 to 1.154, and, with the exception of two samples, it varies from 1.100 to 1.145. The average of the 33 samples was 1.12. The relation of insoluble solids to total solids (expressed as per cent of insoluble solids in total solids) is shown in Table 2. Considering the variations in the methods employed by different manufacturers in the preparation of tomato pulp, the per cent of insoluble solids in the total solids as shown by this column is closer than we might expect, varying in most of the samples from 11 to 14 per cent.

The per cent of sugar in the soluble solids, as shown by Table 2, varies in most of the samples from 50 to 55 per cent. This figure cannot be expected to be constant in different localities and in different years.

The acid, estimated as citric, constitutes in most of the samples from 9 to 10 per cent of the soluble solids.

Of especial interest is the refractive constant of the filtered liquor, shown in the last column of Table 2. The refractive constant of the various samples is much more uniform than might be expected from a product of this nature.

Table 2 is chiefly interesting as affording the data from which Tables 4 and 5 were calculated. The uniformity of the relations shown in Table 5 is such that it is usually possible from one determination on the filtrate and the determination of solids in the pulp by drying to distinguish pulp made from whole tomatoes from that made from trimming stock. For instance, if the specific gravity or index of refraction of a filtrate prepared from a pulp of unknown origin, and the per cent of solids in the pulp by drying, do not agree approximately with the relation between these determinations as shown in Table 5, it may be assumed that the sample was not prepared from whole tomatoes, or that some other substance, such as salt,

has been added. Moreover, trimming stock pulp rarely conforms to the relations found in whole tomato pulp. For instance, the insoluble solids are usually higher and the acid lower in trimming stock pulp.

Trimming Stock Pulp

In Table 3 are given the results of the examination of 21 typical samples of trimming stock pulp prepared at different plants and in different localities. This table is of especial interest in showing that the relations between the results of the various analytical determinations differ from those of whole tomato pulps as given in Table 5. For instance, in No. 1470 the immersion refractometer reading is 45.90, and the per cent of solids is 9.54, whereas, according to Table 5, the per cent of solids in the pulp corresponding to an index of refraction of 45.90 should be 8.57. The specific gravity of the pulp is 1.0373, which, according to Table 5, should correspond to 8.98 instead of 9.54. Of course it cannot be said definitely that a pulp which on examination is found to conform to all the relations shown in Table 5 is necessarily whole tomato pulp. It is entirely possible for an occasional sample of trimming stock pulp to conform to all the relations shown in that table; moreover, the extent to which different samples of trimming stock pulp will vary from the relations shown in Table 5 differs with the manner of preparation. For instance, if a portion of the juice is discarded in the manufacture of trimming stock pulp, as is still the practice of some manufacturers, the variation from whole tomato pulp will be greater than otherwise and the variation will increase with the amount of juice discarded.

Methods of Analysis[1]

These methods may also be applied to the examination of raw tomatoes and canned tomatoes. In applying the relations given below to the results obtained by the examination of tomato pulp or canned tomatoes, it is assumed that no substance such as sugar or salt has been added. If salt is found to be present in excess of the amount normal to tomatoes (from 0.05 to 0.1 per cent), it is necessary to determine the amount and make correction therefor before applying the relations given below.

[1]This chapter is largely taken from an article by Bigelow and Fitzgerald, published in the Journal of Industrial and Engineering Chemistry. The section on Microscopic Examination is substantially a reprint of an article by Bigelow and Donk published in the trade papers in September, 1918. For further information on the analysis of tomato products the Methods of Analysis of the Association of Official Agricultural Chemists (1919) should be consulted.

In examining raw tomatoes, care must be taken to secure a representative sample of the juice. This cannot be done by applying pressure directly, as the juice of the seed receptacles is of different composition from that of the fleshy part of the tomato. It is necessary, therefore, to crush the sample and thoroughly cook it in a flask surrounded by boiling water and connected with a reflux condenser.

Microscopic Examination

The laboratory of the National Canners' Association is frequently asked to examine samples of tomato products to determine whether or not they comply with the Government requirements. In examining these samples we use the Government method (the Howard method), but do not participate in the discussions regarding its merits and shortcomings.

It is our experience that skilled analysts can check themselves and each other with reasonable accuracy, and it is our duty to tell the manufacturer whether his product is legal. Should the Bureau of Chemistry adopt some other method as preferable to the Howard method, it would be our duty to use the new method and continue to serve the industry by telling the manufacturer whether samples submitted by him would pass the Government tests.

With a full understanding of our attitude in this matter many manufacturers of tomato products send samples from time to time for examination. It is made plain in every instance that the results obtained by the examination of a particular sample refer only to the batch from which that sample was taken and may give no indication of the character of any other batch.

Some manufacturers of tomato products use the Howard method as a check on their factory control. For this purpose it is not satisfactory to have samples examined in a laboratory located at a distance from the factory. Even if several samples are examined from a day's run, they probably do not represent all the pulp manufactured on that day. It sometimes happens that one wagonload of tomatoes is almost entirely free of rotting material, whereas the succeeding load contains a considerable amount. Even with inefficient sorting, the pulp made from the first load will show a low microscopic count whereas, unless sorting is exceptionally good, the pulp made from the second load may show a high count. Thus one batch may readily comply with the requirements of the Bureau of Chemistry and the next batch may be outside of those limits. Because of this fact this

laboratory recommends that manufacturers of tomato pulp do not rely upon the microscopic results of a single sample. The only way in which the product may be absolutely controlled by means of the microscopic count is to examine a sample from each batch—that is, from each kettleful or tankful that is evaporated. This is manifestly impossible. It would require several analysts for one plant. Moreover, it is entirely unnecessary.

It has been found that much better results can be secured by having an analyst in the plant to examine samples from time to time. Then, whenever the microscopic count becomes excessive, he can locate the trouble and see that it is corrected.

Manufacturers who desire frequent analyses of their products, therefore, should employ an analyst and arrange to have him instructed in a laboratory conversant with the Howard method as used by the Government. The laboratory of the National Canners' Association makes it a practice to give the necessary instruction in this method to analysts employed by members of the association. These analysts should be carefully selected. Other things being equal, better results should be expected of a college graduate or at least one who has had college training in biology and chemistry. It has been repeatedly demonstrated, however, that a carefully selected man or woman with common school education can learn the method and use it with sufficient accuracy for factory control. The person selected for this work should have good powers of observation and a positive character.

This laboratory has heretofore advised that manufacturers of tomato pulp should not give too much attention to the microscopic count of their product. We have maintained that the expense would be better placed on the sorting belt; that if the sorting and trimming were adequately done, the plant maintained in a sanitary condition and the product manufactured as rapidly as possible, a low microscopic count would be assured. This we still maintain is true. So many cases have come to our attention, however, in which canners have not succeeded in maintaining the degree of sorting necessary with a product of this kind that we have grown to feel that the presence of an analyst working continuously in a plant is an additional safeguard.

The conditions attending the canning of tomatoes are widely different from those attending the manufacture of tomato pulp. The ordinary rot is almost always apparent from the outside of the

tomatoes[1] and is removed by the peelers when preparing tomatoes for canning. Practically none of it, therefore, finds its way into the can. With pulp it is quite different. Any rot which is not removed by sorting and trimming goes into the cyclone and passes into the pulp. With trimming stock pulp, the condition is obviously much worse than with whole tomato pulp. One hundred pounds of tomatoes will yield not far from 85 pounds of cyclone juice. If only trimming stock is made into pulp, however, nearly half the tomatoes are used for canning and the remainder (50 or 55 pounds of trimming stock) will only make something like 35 or 40 pounds of cyclone juice. Yet, since the rot is almost entirely on the outside of the tomatoes, this 35 or 40 pounds made from the trimming stock contains the same amount of molds as the 85 pounds manufactured from the whole tomatoes. The mold count of the trimming stock pulp, therefore, is much higher than that of whole tomato pulp made from the same raw product.

The Bureau of Chemistry condemns tomato pulp whose microscopic examination gives results as high as the following figures:

Molds..............	66 per cent of fields.
Bacteria............	100 million per cubic centimeter.
Yeasts and spores....	125 per 1/60 cubic millimeter.

These figures, of course, apply to the Howard method as employed by the Bureau of Chemistry. The method is entirely arbitrary and results agreeing with those obtained by the Bureau of Chemistry can be obtained only by using this method substantially as it is used by the bureau. An examination of the pulp, therefore, by an analyst who is not thoroughly conversant with this method as it is employed by the Bureau of Chemistry not only is useless but may actually afford a manufacturer a false sense of security which will be greatly to his disadvantage.

Microscopic Equipment Required

The apparatus employed by the Bureau of Chemistry includes apochromatic objectives and compensating oculars. In 1914 it became impossible to obtain these accessories[2] because of the European

[1]Tomatoes are sometimes found with rotten centers of which there is little or no external evidence. This is unusual, however, and the influence of this form of rot under manufacturing conditions is negligible.

[2]Apochromatic objectives may now be obtained but are more expensive than the achromatic.

war and equivalent apparatus of American manufacture was found to give the same results. Both of these forms of apparatus are recognized in the official Howard method which is given below.

This laboratory made a careful study of the accessories available in order to determine what could best be used. It was found that very satisfactory results could be obtained by employing a 10X Huyghenian ocular and a 4 mm. achromatic objective (working distance 0.6 mm.) and a 16 mm. achromatic objective. These accessories require a careful adjustment of light, but with proper use enable an analyst to secure satisfactory results. It is found that the best results are obtained with a rather dark field.

The apparatus necessary for the Howard method, including the accessories mentioned above, may be obtained of two American manufacturers, the Bausch & Lomb Optical Company, of Rochester, N. Y., and the Spencer Lens Company, of Buffalo, N. Y.

There is given below a full list of the optical apparatus required, including catalog numbers of the two manufacturers, as far as numbers have been assigned by them to the various items. In addition to the apparatus given in this list, the analyst should have a 50 c. c. graduated cylinder for measuring and diluting samples. This may be obtained of any dealer in chemical apparatus and at many drug stores. When ordering the optical apparatus the full description as given below should be included.

Optical Apparatus for the Howard Method

Quantity desired	Item	Bausch & Lomb	Spencer
1	Microscope without oculars, objectives or other accessories	FF	44
1	Abbe condenser with two iris diaphrams (lower and upper)	1740	300
1	Double nosepiece	1844	450
1	16 mm. achromatic objective	1021	108
1	4 mm. achromatic objective with working distance of 0.6 mm.	1029	116
1	8 mm. achromatic objective with working distance of 1.6 mm.	1027	112
1	10X Huyghenian ocular	1104	142
1	Mechanical stage	2116	485
1	Substage lamp with Daylite glass	1774	385-B
1	Blood counting chamber (Haemacytometer with ruling of Thoma, Neubauer, Jappert, Brewer or Turk)	3550	1472

6	Cover glasses for same, 20x21 mm., 0.4 thick.........	3595	1460
1	Howard's mold counting chamber (with ¾ inch inner disk) for same................................	3566	Special
6	Cover glasses for same 33 mm. square, 0.6 mm. thick	3598	Special
2	Cases for counting chambers........................	3580	1505

All analysts undertaking the Howard method should secure copies of the two bulletins of the United States Department of Agriculture written by Mr. B. J. Howard—Bulletin 569 on Sanitary Control of Tomato Canning Factories and Bulletin 581, Microscopic Studies on Tomato Products. These bulletins may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., on payment of five cents each in coin.

The details of the method as given below are reprinted from the Methods of Analysis of the Official Agricultural Chemists as amended in 1921.

Apparatus

(*a*) *Compound miscroscope.*—Equipped with apochromatic objectives and compensating oculars, giving magnifications of approximately 90, 180, and 500 diameters. These magnifications can be obtained by the use of 16 and 8 mm. Zeiss apochromatic objectives with X6 and X18 Zeiss compensating oculars, or their equivalents, such as the Spencer 16 and 8 mm. apochromatic objectives[1] with Spencer X10 and X20 compensating oculars, the draw-tube of the microscope being adjusted as directed below.

(*b*) Thoma-Zeiss blood counting cell.[2]

(*c*) Howard mold counting cell.—Constructed like a blood-counting cell but with the inner disk (which need not be ruled) about 19 mm. in diameter.[2]

Molds.—Tentative

Clean the special Howard cell so that Newton's rings are produced between the slide and the cover-glass. Remove the cover and place, by means of a knife blade or scalpel, a small drop of the sample upon the central disk; spread the drop evenly over the disk and cover with the cover-glass so as to give an even spread to the material. It is of the utmost importance that the drop be mixed thoroughly and spread evenly; otherwise the insoluble matter, and consequently the molds, are most abundant at the center of the drop. Squeezing out of the more liquid portions around the margin must be avoided. In a satisfactory mount Newton's rings should be apparent when finally mounted

[1] We are informed that the Bausch and Lomb Optical Co. also furnishes suitable apochromatic objectives and compensating oculars for use in counting molds, yeast and bacteria by the Howard method.

[2] Comment by authors: In using these cells the plane parallel cover glasses furnished with them by maker should be used instead of the ordinary microscope cover-glasses, since the latter are subject to curvatures that introduce errors in the thickness of the mounts.

and none of the liquid should be drawn across the moat and under the cover-glass.

Place the slide under the microscope and examine with a magnification of about 90 diameters and with such adjustment that each field of view covers 1.5 sq. mm. This area is of vital importance and may be obtained by adjusting the draw-tube in such a way that the diameter of the field becomes 1.382 mm. as determined by measurement with a stage micrometer.[1] A 16 mm. Zeiss apochromatic objective with a Zeiss X6 compensating ocular or a Spencer 16 mm. apochromatic objective with a Spencer X10 compensating ocular, or their equivalents, shall be used to obtain this magnification. Under these conditions the amount of liquid examined is .15 cmm. per field. Observe each field as to the presence or absence of mold filaments and note the result as positive or negative. Examine at least 50 fields, prepared from two or more mounts. No field should be considered positive unless the aggregate length of the filaments present exceeds approximately one-sixth of the diameter of the field. Calculate the proportion of positive fields from the results of the examination of all the observed fields and report as percentage of fields containing mold filaments.

Yeasts and Spores.—Tentative

Fill a graduated cylinder with water to the 20 cc. mark, and then add the sample till the level of the mixture reaches the 30 cc. mark. Close the graduate, or pour the contents into an Erlenmeyer flask, and shake the mixture vigorously for 15 to 20 seconds. To facilitate thorough mixing the mixture should not fill more than three-fourths of the container in which the shaking is performed. For tomato sauce or pastes, or products running very high in the number of organisms, or of heavy consistency, 80 cc. of water should be used with 10 cc. or 10 grams of the sample. In the case of exceptionally thick or dry pastes, it may be necessary to make an even greater dilution.

Pour the mixture into a beaker. Thoroughly clean the Thoma-Zeiss counting cell so as to give good Newton's rings. Stir thoroughly the contents of the beaker with a scalpel or knife blade, and then, after allowing to stand 3 to 5 seconds, remove a small drop and place upon the central disk of the Thoma-Zeiss counting cell and cover immediately with the cover-glass, observing the same precautions in mounting the sample as given under 28.[2] Allow the slide to stand not less than 10 minutes before beginning to make the count. Make the count with a magnification of about 180 diameters to obtain which the following combination, or their equivalents, should be employed: 8 mm. Zeiss apochromatic objective with X6 Zeiss compensating ocular, or an 8 mm. Spencer apochromatic objective with X10 Spencer compensating ocular with draw-tube not extended.

Count the number of yeasts and spores [3] on one-half of the ruled squares on

[1] Comment by authors: Obviously after the proper draw-tube length has been secured that adjustment should be noted and always used in making mold counts.

[2] This number refers to the section as given in the Methods of Analysis of the Association of Agricultural Chemists.

[3] Comment by authors: The organisms counted as "yeasts and spores" are the yeast cell and yeast and mold spores, not bacteria spores.

the disk (this amounts to counting the number in 8 of the blocks, each of which contains 25 of the small ruled squares). The total number thus obtained equals the number of organisms in 1/60,000 cc. if a dilution of 1 part of the sample with 2 parts of water is used. If a dilution of 1 part of the sample with 8 parts of water is used the number must be multiplied by 3. In making the counts, the analyst should avoid counting an organism twice when it rests on a boundary line between two adjacent squares.

Bacteria.—Tentative

Estimate the number of rod-shaped bacteria from the mounted sample used in 29[1] (yeasts and spores), but before examination allow the sample to stand not less than 15 minutes after mounting. Employ a magnification of about 500, which may be obtained by the use of an 8 mm. Zeiss apochromatic objective with X18 Zeiss compensating ocular with draw-tube not extended, or an 8 mm. Spencer apochromatic objective with X20 Spencer compensating ocular and a tube length of 190, or their equivalents.[2]

Count and record the number of bacteria having a length greater than one and one-half times their width in an area consisting of five of the small size squares. Count five such areas, preferably one from near each corner of the ruled portion of the slide and one from near the center. Determine the total number of the rod-shaped bacteria per area in the five areas and multiply by 480,000. This gives the number of this type of bacteria per cc. If a dilution of 1 part of the sample with 8 parts of water instead of 1 part of the sample with 2 parts of water is used in making up the sample, then the total count obtained as above must be multiplied by 1,440,000. Omit the micrococcus type of bacteria in making the count. Thus far it has proved impracticable to count the micrococci present, as they are likely to be confused with other bodies frequently present in such products.

Determination of Total Solids

I. By the Examination of the Pulp

The total solids in tomato pulp may be determined by drying *in vacuo* at 70° C.; by drying at atmospheric pressure at the temperature of boiling water; by calculation from the specific gravity of the pulp; or from the per cent of solids, specific gravity or index of refraction of the filtrate. The solids obtained by different methods on 31 samples of pulp are given in Table 4.

(*a*) *By drying*.—By drying either *in vacuo* or at atmospheric pressure, it is our experience that after the sample has reached

[1] This number refers to the section as given in the Methods of Analysis of the Association of Official Agricultural Chemists.

[2] The 4 mm. achromatic objective and the 10X ocular as given in the list of apparatus may also be used to secure this magnification.

apparent dryness, four hours' drying gives complete results. From 2 to 4 grams should be taken for the determination, and enough water added to distribute the sample uniformly over the bottom of a flat-bottomed dish at least 2.5 inches in diameter.

The solids as determined by drying *in vacuo* at 70° C. are about 108.5 per cent of the result obtained by drying at the temperature of boiling water at atmospheric pressure. This figure is the average of the results obtained by the examination of 20 samples of pulp, in all of which the per cent of solids obtained by drying *in vacuo* agree quite closely with the per cent obtained by drying at atmospheric pressure multiplied by 1.085. In 15 of the 20 samples examined, the difference did not exceed 0.10 per cent, and in only one case did it exceed 0.20 per cent. The results obtained by the subsequent examination of a considerable number of other samples confirm this relation.

(*b*) *By calculation from the specific gravity of the pulp.*—There is a very exact relation between the specific gravity of pulp (determined by the method given above) and the per cent of total solids as determined by drying. The solids corresponding to pulps of various specific gravities are given in Table 5, or may be obtained from the following formula which is derived from the same table:

$$\text{Per cent Solids} = 228\ (\text{sp. gr. of pulp} - 1.000) + 19.1\ (\text{sp. gr. of pulp} - 1.015).$$

2. BY THE EXAMINATION OF THE FILTRATE

If a sample of pulp of considerable size be thrown on a folded filter, a filtrate is obtained whose composition has a definite relation to that of the whole pulp.

(*a*) *By drying.*—The per cent of solids in the filtrate may be determined by drying *in vacuo* at 70° C., or under atmospheric pressure at the temperature of boiling water.

As in the case of the drying of pulp, a constant relation is found to exist between the per cent of solids in the filtered liquor as determined by drying *in vacuo* at 70° C., and the per cent of solids as determined by drying at atmospheric pressure at the temperature of boiling water. The per cent of solids in the filtrate obtained by drying at atmospheric pressure, multiplied by 1.125, gives the per cent of solids obtained by drying *in vacuo*. This relation is shown in detail in Table 5.

The per cent of solids in the filtered liquor obtained by drying *in*

TABLE 2.—*Composition of Whole Tomato Pulps*

Sample No.	Composition of pulps: Sp. gr. at 20° C.	Composition of pulps: Total solids (*a*)	Composition of pulps: Insoluble solids	Filtrate from pulps: Sp. gr. at 20° C.	Filtrate from pulps: Solids (*a*)	Filtrate from pulps: Sugar (*d*)	Filtrate from pulps: Acid as citric	Filtrate from pulps: Immersion refractometer 17.5° C.	Ratio of pulp solids to filtrate solids	Insoluble solids in total solids	Solids of filtrate: Sugar (*d*)	Solids of filtrate: Acid	Solids of filtrate: Ratio sugar to acid	Refractive constant of filtered liquor (*f*)
		Per cent	*Per cent*		*Per cent*	*Per cent*	*Per cent*			*Per cent*	*Per cent*	*Per cent*		
1290	1.0252	5.94	0.66	1.0233	5.24	2.41	0.58	36.24	1.133	11.1	46.0	11.1	4.1	0.20556
1291	1.0273	6.54	0.78	1.0252	5.71	3.10	0.53	37.80	1.145	11.9	54.3	9.4	5.8	0.20550
1292	1.0234	5.50	0.80	1.0211	4.88	2.48	0.49	34.51	1.127	14.6	50.8	10.1	5.0	0.20564
1293	1.0293	7.02	0.74	1.0276	6.28	3.35	0.61	40.04	1.118	10.5	53.4	9.7	5.5	0.20548
1294	1.0272	6.48	0.69	1.0256	5.82	3.20	0.55	38.27	1.113	10.6	55.0	9.5	5.8	0.20525
1295	1.0361	8.67	0.95	1.0340	7.69	4.36	0.67	46.03	1.127	11.0	56.8	8.7	6.5	0.20534
1296	1.0380	9.00	1.06	....	8.05	4.47	0.66	46.86	1.117	11.8	55.5	8.2	6.8	....
1297	1.0465	11.20	1.19	1.0446	10.27	5.61	0.89	56.70	1.091	10.6	54.6	8.9	6.3	0.20544
1299	1.0417	10.07	1.23	1.0394	9.09	4.96	0.81	51.75	1.108	12.2	54.6	8.9	6.1	0.20550
1300	1.0322	7.70	0.93	1.0304	6.88	3.55	0.67	42.84	1.119	12.1	51.6	9.7	5.3	0.20546
1301	1.0312	7.36	0.91	....	6.68	3.27	0.69	41.56	1.102	12.4	48.9	10.3	4.8	....
1302	1.0310	7.45	0.91	1.0293	6.61	3.43	0.64	41.76	1.127	12.2	51.9	9.7	5.4	0.20551
1303	1.0340	8.17	0.91	1.0323	7.29	3.77	0.71	44.65	1.120	11.1	51.7	9.7	5.3	0.20549
1304	1.0292	6.88	0.88	1.0274	6.20	3.03	0.64	39.74	1.110	12.8	48.9	10.4	4.7	0.20546
1305	1.0371	9.03	1.19	....	7.98	4.14	0.82	47.30	1.132	13.2	51.9	10.3	5.0	....
1306	1.0370	8.95	0.98	....	8.01	4.71	0.69	47.60	1.117	11.0	58.8	8.7	6.8	....
1307 (*b*)	1.0328	7.86	1.01	1.0308	6.97	3.79	0.66	43.15	1.126	12.9	54.4	9.5	5.7	0.20544
1481	1.0449	10.82	....	1.0421	9.64	5.15	0.99	54.20	1.123	....	53.4	10.3	5.2	0.20545
1482	1.0444	10.83	....	1.0422	9.86	5.62	0.94	54.75	1.100	....	57.0	9.6	6.0	0.20554
1483	1.0464	11.21	....	1.0441	10.19	5.67	0.98	56.45	1.100	....	55.6	9.6	5.8	0.20550
1484	1.0423	10.27	....	1.0396	9.23	5.42	0.81	52.10	1.114	....	58.7	8.8	6.7	0.20544
1485	1.0347	8.55	....	1.0332	7.73	4.35	0.72	45.85	1.106	....	56.3	9.3	6.0	0.20529
1477 (*c*)	1.0610	13.86	....	1.0579	12.75	6.55	0.97	67.15	1.111(*e*)	....	51.4	7.7	6.7	....
1479	1.0411	10.00	1.21	1.0386	8.96	....	....	51.57	1.116	9.8	....	....	....	0.20554
1486	1.0169	4.34	0.62	1.0158	3.76	....	....	....	1.154	14.3	....	....	....	....
1491	1.0198	4.97	0.63	1.0188	4.40	....	....	32.67	1.128	12.7	....	....	....	0.20565
1496	1.0341	8.27	1.15	1.0318	7.31	....	....	44.86	1.131	13.9	....	....	....	0.20554
1515	1.0352	8.56	1.15	1.0331	7.61	....	....	46.20	1.125	13.5	....	....	....	0.20556
1529	1.0209	5.11	0.89	1.0195	4.54	....	....	32.96	1.125	17.4	....	....	....	0.20556
1530	1.0252	6.21	0.98	1.0231	5.42	....	....	36.31	1.145	15.8	....	....	....	0.20553
1531	1.0291	7.17	1.08	1.0273	6.27	....	....	40.09	1.143	15.1	....	....	....	0.20547
1224 (*c*)	1.0486	11.22	0.91	1.0468	10.33	....	....	57.62	1.124(*e*)	11.8	....	....	....	....
1325	1.0327	7.86	0.93	....	6.99	....	....	43.80	1.123	....	....	....	....	....

[a] Determined by drying *in vacuo* at 70° C.
[b] Composite of 1290 to 1306, inclusive.
[c] This sample contained salt.
[d] Expressed as invert.
[e] Salt-free ratio.
[f] Calculated by formula of Lorentz-Lorenz, $\frac{n^2 - 1}{(n^2 + 2)2}$.

Note.—All specific gravities in this bulletin are on a $\frac{20°C}{20°C}$ basis.

TABLE 3.—*Composition of Trimming Stock Pulps*

Sample No.	Composition of pulps			Composition of liquor obtained by filtering pulps					Ratio of pulp solids to filtrate solids	Insoluble solids in total solids	Sugar in solids of liquor	Acid in solids of liquor	Ratio of acid to sugar
	Specific gravity at 20° C.	Total solids (*a*)	Insoluble solids	Specific gravity at 20° C.	Solids (*a*)	Sugar (*e*)	Acid as citric	Immersion refractometer at 17.5° C.					
		Per cent	*Per cent*		*Per cent*	*Per cent*	*Per cent*			*Per cent*	*Per cent*	*Per cent*	
1470	1.0373	9.54	....	1.0337	7.68	4.11	0.58	45.90	1.241	....	53.5	7.6	7.0
1471	1.0385	9.40	....	1.0334	7.62	4.05	0.59	45.75	1.233	....	53.2	7.7	6.9
1470-1	1.0349	8.56	....	1.0302	7.11	....	....	42.87	1.203	....	....	....	....
1470-2	1.0316	7.88	....	1.0279	6.55	....	....	40.75	1.203	....	....	....	....
1470-3	1.0284	7.00	....	....	5.83	....	....	37.80	1.201	....	....	....	....
1470-4	1.0258	6.62	....	1.0232	5.53	....	....	36.40	1.197	....	....	....	....
1471-1	1.0334	8.12	....	1.0288	6.86	....	....	41.60	1.184	....	....	....	....
1471-2	1.0258	6.41	....	1.0227	5.41	....	....	36.10	1.184	....	....	....	....
1471-3	1.0299	7.48	....	1.0275	6.14	....	....	39.25	1.218	....	....	....	....
1471-4	1.0191	4.74	....	1.0168	3.94	....	....	30.35	1.203	....	....	....	....
1572	1.0424	10.28	....	1.0400	9.28	....	....	52.47	1.109	....	....	....	....
1573	1.0392	9.53	1.22	1.0369	8.53	....	....	49.33	1.117	12.8	....	....	....
1574	1.0427	10.29	1.17	1.0401	9.29	....	....	52.40	1.109	11.4	....	....	....
1575	1.0386	9.73	1.29	1.0369	8.28	....	....	49.37	1.175	13.3	....	....	....
1662 (*b*)	1.0204	4.85	0.18	1.0201	4.65	....	....	33.27	1.042	3.7	....	....	....
1664 (*c*)	1.0577	13.20	0.62	1.0566	12.70	....	....	66.92	1.040	4.7	....	....	....
1665	1.0331	7.74	1.10	1.0304	6.89	....	....	42.65	1.123	14.3	....	....	....
701	1.0200	4.89	0.72	1.0184	4.29	2.35	0.30	32.09	1.140	14.7	54.8	7.0	7.8
703 (*d*)	1.0180	4.24	0.10	1.0178	4.15	2.32	0.29	32.09	1.022	2.4	55.9	7.0	8.0
705	1.0388	9.85	1.83	1.0359	8.08	4.07	0.51	47.85	1.220	18.6	50.4	6.2	8.0
706	1.0333	8.35	0.98	....	7.29	3.51	0.46	44.69	1.145	11.7	48.3	6.3	7.6

[a] Determined by drying *in vacuo* at 70° C.
[b] Unconcentrated tomato juice from peeling table.
[c] No. 1662 concentrated.
[d] Clear liquor separated from unconcentrated pulp on standing.
[e] Expressed as invert.

TABLE 4.—*Comparison of Methods for the Determination and Calculation of Solids in Whole Tomato Pulp*

Sample No.	Solids in liquor from filtered pulp				Solids in whole pulp				
	By drying *in vacuo* at 70° C.	Calculated from—			By drying *in vacuo* at 70° C.	Calculated from immersion refractometer reading	Calculated from specific gravity of—		
		Immersion refractometer reading	Specific gravity[1]	Specific gravity[2]			Filtered liquor[3]	Whole pulp	Filtered liquor[4]
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1290....	5.24	5.31	5.35	5.35	5.94	5.95	6.00	5.97	5.99
1291....	5.71	5.67	5.78	5.80	6.54	6.36	6.48	6.47	6.50
1292....	4.88	4.87	4.85	4.85	5.50	5.47	5.44	5.52	5.43
1293....	6.28	6.21	6.33	6.35	7.02	6.96	7.10	6.98	7.11
1294....	5.82	5.79	5.87	5.89	6.48	6.49	6.58	6.45	6.60
1295....	7.69	7.67	7.82	7.82	8.67	8.59	8.77	8.63	8.76
1296....	8.05	7.88	....	....	9.00	8.83	....	9.11	....
1297....	10.27	10.27	10.25	10.26	11.20	11.50	11.47	11.20	11.49
1299....	9.09	9.06	9.05	9.06	10.07	10.15	10.14	10.02	10.15
1300....	6.88	6.91	6.98	6.99	7.70	7.75	7.82	7.68	7.83
1301....	6.68	6.59	....	....	7.36	7.38	....	7.43	....
1302....	6.61	6.64	6.73	6.74	7.45	7.44	7.54	7.40	7.55
1303....	7.29	7.34	7.42	7.43	8.17	8.23	8.33	8.12	8.32
1304....	6.20	6.16	6.30	6.30	6.88	6.90	7.06	6.95	7.06
1305....	7.98	7.98	....	....	9.03	8.94	....	8.88	....
1306....	8.01	8.05	....	....	8.95	9.02	....	8.86	....
1307....	6.97	6.96	7.08	7.08	7.86	7.81	7.93	7.83	7.93
1481....	9.64	9.67	9.68	9.68	10.82	10.83	10.84	10.80	10.84
1482....	9.86	9.81	9.70	9.71	10.83	10.98	10.86	10.70	10.88
1483....	10.19	10.21	10.15	10.14	11.21	11.43	11.36	11.17	11.36
1484....	9.23	9.15	9.10	9.11	10.27	10.25	10.19	10.17	10.20
1485....	7.73	7.64	7.63	7.64	8.55	8.56	8.55	8.30	8.56
1479....	8.96	9.03	8.87	8.88	10.00	10.10	9.94	9.88	9.85
1486....	3.76	....	3.62	3.63	4.34	....	4.05	3.90	4.07
1491....	4.40	4.44	4.30	4.32	4.97	4.97	4.82	4.62	4.84
1496....	7.31	7.39	7.30	7.31	8.27	8.28	8.18	8.15	8.29
1515....	7.61	7.70	7.60	7.61	8.56	8.63	8.52	8.40	8.52
1529....	4.54	4.52	4.47	4.49	5.11	5.06	5.01	4.90	5.03
1530....	5.42	5.32	5.30	5.31	6.21	5.97	5.94	5.97	5.95
1531....	6.27	6.25	6.27	6.28	7.17	7.01	7.04	6.92	7.03
1325....	6.99	7.13	....	....	7.86	7.99	....	7.81	....

[1] From formula on page 30.

[2] The solution factor of O'Sullivan (J. Chem. Soc., 1876, p. 129) was employed with slight modification. The formula employed was $\frac{1000(d - 1000)}{4.35}$ = per cent solids. In this formula d = specific gravity of solution at 20° C.

[3] From formula on page 31.

[4] For these figures the formula of footnote 2 was employed and the results multiplied by 1.12

TABLE 5.—*Tomato Pulp and Filtered Liquor*

Whole pulp			Filtrate from pulp			
Solids by drying		Specific gravity at 20° C.	Solids by drying		Immersion refractometer reading at 17.5° C.	Specific gravity at 20° C.
In vacuo at 70° C.	At atmospheric pressure 100° C.		*In vacuo* at 70° C.	At atmospheric pressure 100° C.		
Per cent	*Per cent*		*Per cent*	*Per cent*		
3.42	3.15	1.0150	3.05	2.71	26.9	1.0133
3.47	3.20	1.0152	3.10	2.75	27.1	1.0136
3.53	3.25	1.0155	3.15	2.80	27.3	1.0138
3.58	3.30	1.0157	3.20	2.85	27.5	1.0140
3.64	3.35	1.0159	3.25	2.89	27.7	1.0142
3.70	3.41	1.0161	3.30	2.93	27.9	1.0144
3.76	3.46	1.0163	3.35	2.97	28.1	1.0146
3.81	3.51	1.0166	3.40	3.02	28.3	1.0149
3.87	3.56	1.0168	3.45	3.07	28.6	1.0151
3.92	3.61	1.0170	3.50	3.11	28.8	1.0153
3.98	3.67	1.0172	3.55	3.15	29.0	1.0155
4.03	3.72	1.0174	3.60	3.20	29.2	1.0157
4.09	3.77	1.0177	3.65	3.24	29.4	1.0160
4.15	3.82	1.0179	3.70	3.28	29.6	1.0162
4.20	3.87	1.0181	3.75	3.33	29.8	1.0164
4.26	3.93	1.0183	3.80	3.38	30.0	1.0166
4.31	3.98	1.0185	3.85	3.42	30.3	1.0168
4.37	4.03	1.0188	3.90	3.46	30.5	1.0170
4.43	4.08	1.0190	3.95	3.51	30.7	1.0173
4.48	4.13	1.0192	4.00	3.55	30.9	1.0175
4 54	4.18	1.0194	4.05	3.60	31.1	1.0177
4.59	4.23	1.0197	4.10	3.64	31.3	1.0179
4.65	4.28	1.0199	4.15	3.69	31.5	1.0181
4.71	4.33	1.0201	4.20	3.73	31.7	1.0183
4.76	4.38	1.0203	4.25	3.78	31.9	1.0185
4.82	4.44	1.0205	4.30	3.82	32.1	1.0188
4.87	4.49	1.0208	4.35	3.86	32.3	1.0190
4.93	4.54	1.0210	4.40	3.91	32.5	1.0192
4.99	4.59	1.0212	4.45	3.95	32.7	1.0194
5.04	4.64	1.0215	4.50	4.00	32.9	1.0196

TABLE 5.—*Tomato Pulp and Filtered Liquor*—Continued

Whole pulp			Filtrate from pulp			
Solids by drying		Specific gravity at 20°C.	Solids by drying		Immersion refractometer reading at 17.5°C.	Specific gravity at 20°C.
In vacuo at 70°C.	At atmospheric pressure 100°C.		*In vacuo* at 70°C.	At atmospheric pressure 100°C.		
Per cent	*Per cent*		*Per cent*	*Per cent*		
5.10	4.70	1.0217	4.55	4.04	33.1	1.0198
5.16	4.75	1.0219	4.60	4.09	33.3	1.0200
5.21	4.80	1.0222	4.65	4.13	33.6	1.0203
5.27	4.85	1.0224	4.70	4.18	33.8	1.0205
5.33	4.90	1.0226	4.75	4.22	34.0	1.0207
5.38	4.96	1.0228	4.80	4.26	34.2	1.0209
5.44	5.01	1.0230	4.85	4.31	34.4	1.0211
5.49	5.06	1.0233	4.90	4.36	34.6	1.0213
5.55	5.11	1.0235	4.95	4.40	34.8	1.0216
5.60	5.16	1.0237	5.00	4.44	35.0	1.0218
					35.2	
5.66	5.21	1.0240	5.05	4.49	35.4	1.0220
5.72	5.26	1.0242	5.10	4.53	35.6	1.0223
5.77	5.31	1.0244	5.15	4.58	35.8	1.0225
5.83	5.36	1.0247	5.20	4.62	36.0	1.0227
5.88	5.41	1.0249	5.25	4.66		1.0229
5.94	5.47	1.0251	5.30	4.71	36.2	1.0231
6.00	5.52	1.0253	5.35	4.75	36.4	1.1333
6.05	5.57	1.0256	5.40	4.80	36.6	0.0235
6.11	5.62	1.0258	5.45	4.84	36.8	1.0238
6.16	5.67	1.0260	5.50	4.89	37.1	1.0240
6.22	5.73	1.0263	5.55	4.93	37.3	1.0242
6.28	5.78	1.0265	5.60	4.98	37.5	1.0244
6.33	5.83	1.0267	5.65	5.02	37.7	1.0246
6.39	5.88	1.0270	5.70	5.06	37.9	1.0249
6.45	5.93	1.0272	5.75	5.11	38.1	1.0251
6.50	5.99	1.0274	5.80	5.15	38.3	1.0253
6.56	6.04	1.0276	5.85	5.20	38.5	1.0255
6.61	6.09	1.0279	5.90	5.24	38.7	1.0257
6.67	6.14	1.0281	5.95	5.29	38.9	1.0259
6.72	6.19	1.0283	6.00	5.33	39.1	1.0261

TABLE 5.—*Tomato Pulp and Filtered Liquor*—Continued

Whole pulp			Filtrate from pulp			
Solids by drying		Specific gravity at 20 °C.	Solids by drying		Immersion refractometer reading at 17.5° C.	Specific gravity at 20° C.
In vacuo at 70° C.	At atmospheric pressure 100° C.		*In vacuo* at 70° C.	At atmospheric pressure 100° C.		
Per cent	*Per cent*		*Per cent*	*Per cent*		
6.78	6.24	1.0285	6.05	5.38	39.3	1.0263
6.84	6.29	1.0288	6.10	5.42	39.5	1.0266
6.89	6.35	1.0290	6.15	5.46	39.7	1.0268
6.95	6.41	1.0292	6.20	5.51	39.9	1.0270
7.01	6.46	1.0294	6.25	5.56	40.1	1.0272
7.06	6.51	1.0297	6.30	5.60	40.3	1.0274
7.12	6.56	1.0299	6.35	5.64	40.6	1.0277
7.17	6.61	1.0301	6.40	5.69	40.8	1.0279
7.23	6.66	1.0304	6.45	5.73	41.0	1.0281
7.28	6.71	1.0306	6.50	5.78	41.2	1.0283
7.34	6.76	1.0308	6.55	5.82	41.4	1.0285
7.40	6.82	1.0310	6.60	5.86	41.6	1.0287
7.45	6.87	1.0313	6.65	5.91	41.8	1.0290
7.51	6.92	1.0315	6.70	5.95	42.0	1.0292
7.56	6.97	1.0317	6.75	6.00	42.2	1.0294
7.62	7.02	1.0320	6.80	6.04	42.4	1.0296
7.68	7.08	1.0322	6.85	6.09	42.6	1.0298
7.74	7.13	1.0324	6.90	6.14	42.8	1.0300
7.79	7.18	1.0326	6.95	6.18	43.1	1.0303
7.85	7.23	1.0329	7.00	6.22	43.3	1.0305
7.90	7.28	1.0331	7.05	6.26	43.5	1.0307
7.96	7.33	1.0333	7.10	6.31	43.7	1.0309
8.02	7.38	1.0336	7.15	6.36	43.9	1.0311
8.07	7.43	1.0338	7.20	6.40	44.1	1.0313
8.12	7.48	1.0340	7.25	6.44	44.3	1.0315
8.18	7.54	1.0342	7.30	6.48	44.5	1.0318
8.24	7.59	1.0345	7.35	6.53	44.7	1.0320
8.30	7.64	1.0347	7.40	6.58	44.9	1.0322
8.35	7.69	1.0349	7.45	6.62	45.1	1.0324
8.40	7.74	1.0352	7.50	6.66	45.3	1.0326

TABLE 5.—*Tomato Pulp and Filtered Liquor*—Continued

Whole pulp			Filtrate from pulp			
Solids by drying			Solids by drying			
In vacuo at 70° C.	At atmospheric pressure 100° C.	Specific gravity at 20° C.	*In vacuo* at 70° C.	At atmospheric pressure 100° C.	Immersion refractometer reading at 17.5° C.	Specific gravity at 20° C.
Per cent	*Per cent*		*Per cent*	*Per cent*		
8.46	7.79	1.0354	7.55	6.71	45.5	1.0328
8.52	7.84	1.0356	7.60	6.76	45.7	1.0331
8.57	7.89	1.0358	7.65	6.80	45.9	1.0333
8.63	7.95	1.0361	7.70	6.84	46.2	1.0335
8.68	8.00	1.0363	7.75	6.89	46.4	1.0337
8.74	8.05	1.0365	7.80	6.93	46.6	1.0339
8.80	8.11	1.0367	7.85	6.98	46.8	1.0341
8.86	8.16	1.0370	7.90	7.02	47.0	1.0344
8.91	8.21	1.0372	7.95	7.07	47.2	1.0346
8.96	8.26	1.0374	8.00	7.11	47.4	1.0348
9.02	8.31	1.0377	8.05	7.16	47.6	1.0350
9.08	8.36	1.0379	8.10	7.20	47.8	1.0352
9.14	8.41	1.0381	8.15	7.24	48.0	1.0354
9.19	8.46	1.0383	8.20	7.28	48.2	1.0357
9.25	8.51	1.0386	8.25	7.33	48.4	1.0359
9.30	8.57	1.0388	8.30	7.38	48.6	1.0361
9.36	8.62	1.0390	8.35	7.42	48.8	1.0363
9.42	8.67	1.0393	8.40	7.46	49.0	1.0366
9.47	8.72	1.0395	8.45	7.51	49.2	1.0368
9.53	8.77	1.0397	8.50	7.55	49.4	1.0370
9.58	8.83	1.0400	8.55	7.60	49.6	1.0372
9.64	8.88	1.0402	8.60	7.64	49.8	1.0374
9.70	8.93	1.0404	8.65	7.68	50.0	1.0376
9.75	8.98	1.0406	8.70	7.73	50.2	1.0379
9.80	9.03	1.0408	8.75	7.78	50.4	1.0381
9.86	9.09	1.0410	8.80	7.82	50.7	1.0383
9.92	9.14	1.0413	8.85	7.86	50.9	1.0385
9.97	9.19	1.0415	8.90	7.91	51.1	1.0387
10.02	9.24	1.0417	8.95	7.95	51.3	1.0389
10.08	9.29	1.0419	9.00	8.00	51.5	1.0392

TABLE 5.—*Tomato Pulp and Filtered Liquor*—Continued

Whole pulp			Filtrate from pulp			
Solids by drying		Specific gravity at 20° C.	Solids by drying		Immersion refractometer reading at 17.5° C.	Specific gravity at 20° C.
In vacuo at 70° C.	At atmospheric pressure 100° C.		*In vacuo* at 70° C.	At atmospheric pressure 100° C.		
Per cent	*Per cent*		*Per cent*	*Per cent*		
10.14	9.35	1.0421	9.05	8.05	51.7	1.0394
10.19	9.40	1.0424	9.10	8.09	51.9	1.0396
10.25	9.45	1.0426	9.15	8.13	52.1	1.0398
10.30	9.50	1.0428	9.20	8.18	52.3	1.0400
10.35	9.55	1.0430	9.25	8.22	52.5	1.0402
10.41	9.60	1.0433	9.30	8.27	52.7	1.0404
10.47	9.65	1.0435	9.35	8.31	52.9	1.0406
10.52	9.70	1.0437	9.40	8.35	53.1	1.0409
10.58	9.75	1.0440	9.45	8.40	53.3	1.0411
10.64	9.80	1.0442	9.50	8.45	53.5	1.0413
10.70	9.86	1.0444	9.55	8.49	53.7	1.0415
10.75	9.91	1.0447	9.60	8.53	53.9	1.0417
10.80	9.96	1.0449	9.65	8.58	54.1	1.0419
10.86	10.01	1.0451	9.70	8.62	54.3	1.0422
10.91	10.06	1.0453	9.75	8.67	54.5	1.0424
10.97	10.11	1.0456	9.80	8.71	54.7	1.0426
11.02	10.16	1.0458	9.85	8.75	55.0	1.0428
11.08	10.21	1.0461	9.90	8.80	55.2	1.0430
11.14	10.26	1.0463	9.95	8.85	55.4	1.0433
11.20	10.31	1.0465	10.00	8.89	55.6	1.0435
11.25	10.37	1.0467	10.05	8.93	55.8	1.0437
11.30	10.42	1.0469	10.10	8.98	56.0	1.0439
11.36	10.47	1.0472	10.15	9.02	56.2	1.0441
11.41	10.52	1.0474	10.20	9.07	56.4	1.0444
11.47	10.57	1.0476	10.25	9.11	56.6	1.0446
11.53	10.63	1.0478	10.30	9.15	56.8	1.0448
11.59	10.68	1.0481	10.35	9.20	57.0	1.0450
11.64	10.73	1.0483	10.40	9.25	57.2	1.0452
11.70	10.78	1.0485	10.45	9.29	57.4	1.0454
11.75	10.83	1.0487	10.50	9.33	57.6	1.0457

TABLE 5.—*Tomato Pulp and Filtered Liquor*—Continued

Whole pulp			Filtrate from pulp			
Solids by drying		Specific gravity at 20° C.	Solids by drying		Immersion refractometer reading at 17.5° C.	Specific gravity at 20° C.
In vacuo at 70° C.	At atmospheric pressure 100° C.		*In vacuo* at 70° C.	At atmospheric pressure 100° C.		
Per cent	*Per cent*		*Per cent*	*Per cent*		
11.81	10.89	1.0490	10.55	9.38	57.8	1.0459
11.87	10.94	1.0492	10.60	9.42	58.0	1.0461
11.93	10.99	1.0494	10.65	9.47	58.2	1.0463
11.99	11.04	1.0496	10.70	9.51	58.4	1.0465
12.05	11.09	1.0499	10.75	9.55	58.6	1.0467
12.10	11.15	1.0501	10.80	9.60	58.8	1.0469
12.15	11.20	1.0503	10.85	9.65	59.0	1.0471
12.21	11.25	1.0505	10.90	9.70	59.2	1.0474
12.26	11.30	1.0508	10.95	9.74	59.4	1.0476
12.32	11.35	1.0510	11.00	9.78	59.6	1.0478
12.37	11.40	1.0512	11.05	9.82	59.9	1.0480
12.43	11.45	1.0515	11.10	9.87	60.1	1.0482
12.49	11.50	1.0517	11.15	9.92	60.3	1.0484
12.55	11.55	1.0519	11.20	9.96	60.5	1.0487
12.60	11.60	1.0522	11.25	10.00	60.7	1.0489
12.65	11.66	1.0524	11.30	10.04	60.9	1.0491
12.71	11.71	1.0526	11.35	10.09	61.1	1.0493
12.77	11.76	1.0528	11.40	10.13	61.3	1.0495
12.83	11.81	1.0531	11.45	10.18	61.5	1.0498
12.88	11.86	1.0533	11.50	10.22	61.7	1.0500
12.94	11.92	1.0535	11.55	10.27	61.9	1.0502
12.99	11.97	1.0538	11.60	10.31	62.1	1.0504
13.05	12.02	1.0540	11.65	10.35	62.3	1.0506
13.10	12.07	1.0542	11.70	10.40	62.5	1.0508
13.16	12.12	1.0544	11.75	10.45	62.7	1.0511
13.22	12.18	1.0547	11.80	10.49	62.9	1.0513
13.27	12.23	1.0549	11.85	10.53	63.1	1.0515
13.32	12.28	1.0551	11.90	10.58	63.3	1.0517
13.38	12.33	1.0554	11.95	10.63	63.5	1.0519
13.44	12.38	1.0556	12.00	10.67	63.7	1.0521

TABLE 5.—*Tomato Pulp and Filtered Liquor*—Continued

Whole pulp			Filtrate from pulp			
Solids by drying		Specific gravity at 20° C.	Solids by drying		Immersion refractometer reading at 17.5° C.	Specific gravity at 20° C.
In vacuo at 70° C.	At atmospheric pressure 100°C.		*In vacuo* at 70° C.	At atmospheric pressure 100° C.		
Per cent	*Per cent*		*Per cent*	*Per cent*		
13.50	12.44	1.0558	12.05	10.71	64.0	1.0523
13.55	12.49	1.0560	12.10	10.75	64.2	1.0525
13.60	12.54	1.0562	12.15	10.80	64.4	1.0527
13.66	12.59	1.0565	12.20	10.84	64.6	1.0529
13.72	12.64	1.0567	12.25	10.89	64.8	1.0531
13.78	12.70	1.0569	12.30	10.94	65.0	1.0533
13.83	12.75	1.0572	12.35	10.98	65.2	1.0535
13.89	12.80	1.0574	12.40	11.02	65.4	1.0537
13.95	12.85	1.0576	12.45	11.07	65.6	1.0539
14.01	12.90	1.0579	12.50	11.11	65.8	1.0541

vacuo, multiplied by 1.12, gives the per cent of solids in the original pulp obtained by drying *in vacuo.* This relationship is shown in Table 2, in the column headed "Ratio of pulp solids to filtrate solids," and also in Table 5.

Of the 33 samples shown in Table 2, the result obtained by multiplying the per cent of solids in the filtrate (obtained by drying *in vacuo*) by the factor 1.12 is very nearly identical with the per cent of solids in the pulp (obtained by drying *in vacuo*). In 22 of the 33 samples the difference between these two figures is less than 0.1 per cent. In 17 samples it is less than 0.06 per cent, and in 13 samples it is less than 0.05 per cent. In only two samples does it exceed 0.17 per cent.

(*b*) *By calculation from the specific gravity of the filtrate.*—The specific gravity of the filtered liquor may be determined by means of an ordinary pycnometer. From the specific gravity at 20° C., the per cent of solids in the filtrate as determined by drying *in vacuo* at 70° C. may be obtained from Table 5. It may also be calculated by the following formula, which was derived from the same table:

Per cent SOLIDS IN FILTRATE = 230 (sp. gr. of filtrate − 1.000).

The per cent of solids in the pulp may also be ascertained from the specific gravity of the filtrate at 20° C., from Table 5. The same results may be obtained from the following formula, which was derived from Table 4:

Per cent SOLIDS IN PULP = 257.5 (sp. gr. of filtrate at 20° C. − 1.000).

It is of interest to note that the table suggested by Windisch for the determination of extract in wine (Bureau of Chemistry, U. S. Dept. Agri., Bull. 107, revised, Table V) may be employed to determine solids in tomato pulp from the specific gravity of the filtered liquor from the same. If the specific gravity of the liquor be determined at 20° C., the figures in the adjoining column, under "Extract," correspond very closely to the per cent of total solids in the original pulp. A still closer agreement is obtained if the figure 0.05 be deducted from the percentage of extract given in the table.

(*c*) *By calculation from the index of refraction of the filtrate.*— The index of refraction of the liquor obtained by filtering tomato pulp may be determined by means of either the Zeiss-Abbé refractometer, or the immersion refractometer at the temperature of 17.5° C. The latter is preferable as it permits of much greater accuracy. The corresponding percentage of solids in the filtrate and the percentage of solids in the pulp from which it is prepared may be ascertained from the index of refraction by Table 5. The per cent of solids in the filtrate may also be calculated from the scale reading of the immersion refractometer at 17.5° C. by the following formula, which is derived from Table 5:

Per cent SOLIDS IN FILTRATE = 0.258 (scale reading − 15) − 0.0165 (scale reading − 26.4).

If the index of refraction has been determined by means of an Abbé refractometer, the per cent of solids in the filtrate may be calculated by the following formula:

Per cent SOLIDS IN FILTRATE = 666 (n_D − 1.3332) − 20.7 (n_D − 1.3376).

The per cent of total solids in tomato pulp may also be ascertained from the index of refraction of the liquor prepared by filtering the pulp as shown in Table 5; or it may be calculated from the immersion refractometer reading by the following formula, which is derived from Table 5:

Per cent SOLIDS IN PULP = 0.289 (scale reading of filtrate − 15) − 0.0185 (scale reading − 26.4).

If the index of refraction of the filtrate has been determined by

means of an Abbé refractometer, the per cent of solids in the pulp may be calculated by the following formula:

$$\text{Per cent Solids in Pulp} = 748\,(n_D - 1.3332) - 25.5\,(n_D - 1.3376).$$

It is of interest to note that the relation between the index of refraction of the liquor obtained by filtering tomato pulp and the per cent of solids in that liquid is very similar to the relation between the index of refraction and dissolved solids in beer and wine extract, as shown in the table prepared by Wagner.[1]

In the formula given above, as well as in Table 5, it is assumed that salt is absent. If it be desired to calculate the percentage of solids in a sample containing salt from the index of refraction of the filtrate, it is necessary first to determine the amount of salt present and make correction therefor (see p. 34). For this purpose the table of Wagner[2] may be employed. The correction of the immersion refractometer reading amounts to 0.45 for each tenth per cent of salt present.

This correction is necessary if the percentage of solids be determined by drying, or calculated from specific gravity.

Determination of Insoluble Solids

Transfer 20 grams of the pulp to an eight-ounce nursing bottle, nearly filled with hot water, mix by shaking, and centrifuge until the insoluble matter is collected in a cake in the bottom of the bottle. Transfer the supernatant liquor onto a double, tared filter paper covering the bottom of a Büchner funnel, using suction to facilitate filtration.

Again fill the nursing bottle with hot water, stir the cake of insoluble solids so that it is thoroughly mixed with the water, centrifuge, and decant the supernatant liquor on the filter. Repeat the centrifuging and the filtration of the supernatant liquor once more, and then finally transfer the insoluble solids to the filter paper and thoroughly wash with hot water. Dry the paper and insoluble solids, and weigh. The insoluble solids are quite hydroscopic and the weight must be taken quickly.

Determination of Sugar

The sugar of tomatoes is probably always present as invert sugar. If cane sugar is ever present in the raw product it its doubtless inverted during the concentration of pulp. The per cent of sugar given in Tables 2 and 3 was determined by the method of Munson and Walker.[3]

[1] "Ueber quantitative Bestimmungen wässeriger Lösungen mit dem Zeiss-schen Eintauch-refraktometer," Table XVII.

[2] *Ibid.*, Table I.

[3] Methods of Analysis of the Association of Official Agricultural Chemists (1919).

Determination of Acidity

Accurate results cannot be obtained by the titration of tomato products in the presence of the insoluble solids. If it be desired to determine the acidity in the entire sample of tomatoes or tomato pulp rather than in the expressed juice, the insoluble solids should first be removed by the method given in the determination of insoluble solids or by filtration through filter paper. The per cent of acid given in Tables 2 and 3 was obtained by titrating the liquor obtained by filtering the pulp. In products of this nature, the addition of an alkali causes a brownish color which has a tendency to obscure the end point shown by the indicator. To obviate this, the sample should be diluted to at least 200 cc. and a larger amount of indicator employed than is necessary with a clear solution. The following details are suggested.

Dilute 20 grams of the filtrate under examination with over 200 cc. of water. Add at least ½ cc. of phenolphthalein solution (prepared by dissolving 1 gram of phenolphthalein in 100 cc. of 95 per cent alcohol) and titrate with sodium hydroxide until the end point is obtained. Add 1 cc. of tenth-normal hydrochloric acid, heat the solution quickly to boiling and boil one minute to expel carbon dioxide. Cool the solution quickly to about room temperature, and then add tenth-normal sodium hydroxide until the end point is obtained. The volume of hydrochloric acid added must, of course, be taken into consideration in the final result. The filtrate may also be titrated direct with tenth-normal sodium hydroxide solution with satisfactory results.

Determination of Salt

This laboratory has been using the following rapid method which gives results agreeing closely with results obtained by the analysis of the ash:

Weigh out 20 grams of pulp, dilute in a volumetric flask to 200 cc., filter and titrate an aliquot portion with standard silver nitrate solution, using potassium chromate as indicator. The acidity of tomato pulp is not sufficient to interfere with this determination.

Determination of Specific Gravity[1]

The specific gravity of tomato pulp is used as one criterion for establishing the value of pulp that is offered for sale and is also used in connection with the manufacture of pulp to determine the point at which evaporation should be stopped.

In the former case there is ample time for making the examination, and conditions may be established which permit a reasonable degree of accuracy in the work.

[1] All specific gravities given in this bulletin are on a $\frac{20°C}{20°C}$ basis.

In the determination of the specific gravity of hot pulp during the process of its evaporation speed is essential, and the conditions of a manufacturing plant do not always permit a high degree of accuracy. It becomes necessary, therefore, to consider what methods may give the highest degree of accuracy obtainable under the conditions of the work and at the same time afford quick results.

Tomato pulp, owing to its high viscosity, retains a large quantity of air bubbles which increase the volume of the pulp and hence interfere with the accuracy of the determination of specific gravity. In working with cold pulp this air may be eliminated by whirling in a centrifuge. With hot pulp that operation is impossible, and the specific gravity must be determined in the presence of the air bubbles mentioned. Moreover, in working with cold pulp the temperature can be more accurately controlled, and the error caused by variation in temperature can be corrected. With hot pulp these conditions cannot be obtained nearly so well. The determination of specific gravity of hot pulp is therefore only roughly approximate at best. Where time permits it is strongly advisable to cool the pulp under conditions that prevent evaporation before determining specific gravity.

The importance of accuracy in the determination of specific gravity in tomato pulp is discussed on page 50.

Methods are given below for the determination of specific gravity in both hot and cold pulp.

When salt has been added, the amount should be determined and a correction applied by deducting .007 from the specific gravity for each per cent of salt present.

(a) COLD PULP AFTER CENTRIFUGING TO ELIMINATE AIR BUBBLES

This method may be employed for pulp of any degree of concentration or for unconcentrated cyclone juice. A specific gravity flask such as is shown in Figure 1 is used together with a "2-bottle" Babcock milk tester (the centrifuge referred to below). The flask may be obtained of Eimer & Amend, Third Avenue, 18th to 19th Streets, New York City, or of Emil Greiner & Co., 55 Fulton Street, New York City, and in ordering it should be designated as "specific gravity flask for tomato pulp of Pyrex glass with a capacity of about 125 cc." The "2-bottle" Babcock milk tester may be obtained of any dairy supply house. It may also be obtained of any dealer in chemical apparatus by designating it as E. & A. No. 1833.

The specific gravity flask may be calibrated as follows:

Obtain the weight of the flask after thoroughly cleaning and drying, fill to overflowing with water (preferably boiled and cooled distilled water) and remove the excess water from the mouth of the flask by means of a straight edge. Wipe dry and weigh immediately. If the flask full of water is weighed at any other temperature than 20° C. (68° F.) a correction must be made to obtain the weight at that temperature. These corrections are as follows:

Temperature		Correction to be added with flasks having a volume of—	
Fahrenheit	Centigrade	125 cc.	400 cc.
		Grams	*Grams*
69	20.6	.02	.05
70	21.1	.03	.09
71	21.7	.05	.14
72	22.2	.06	.20
73	22.8	.08	.25
74	23.3	.09	.30
75	23.9	.11	.35
76	24.4	.13	.41
77	25.0	.15	.47
78	25.6	.17	.53
79	26.1	.18	.59
80	26.7	.20	.65
81	27.2	.22	.71
82	27.8	.24	.77
83	28.3	.26	.83
84	28.9	.28	.89
85	29.4	.30	.96
86	30.0	.32	1.02

If it is desired to use somewhat larger samples and thus secure correspondingly more accurate results, a similar flask, but made somewhat larger (capacity approximately 400 cc.), may be employed. Such a flask, with a diameter of a little over 3 inches, is illustrated in Figure 2. This larger flask will not fit into the Babcock tester, and when it is used a special head for the Babcock tester must be made.

Such a head is illustrated in Figure 3, and can be made by any good tinner.

The larger flask shown in Figure 2 holds a heavier weight than the Babcock machine is intended to carry, and the advisability of its use is

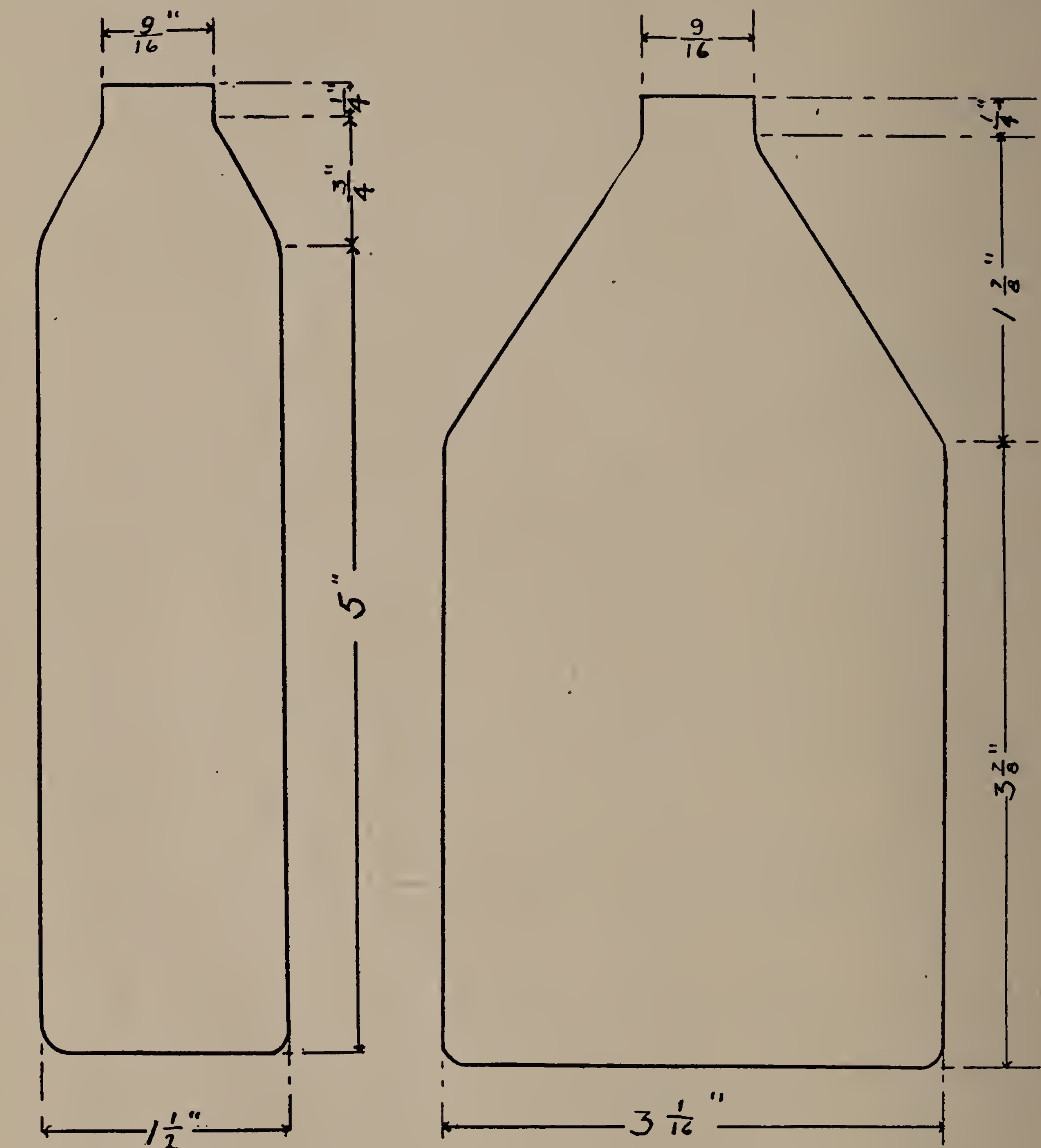

Fig. 1. Small Specific Gravity Flask.

Fig. 2. Large Specific Gravity Flask.

Dimensions given are outside measurements. Thickness of walls is about 3/64 in.

perhaps questionable. In any case, whatever size flask is used, it is important to build a guard around the centrifuge in order to protect the operator when the apparatus gives way, as it eventually will.

The details of the method of determining specific gravity by the use of this apparatus are as follows:

Fill the flask shown in Figure 1 with the sample of pulp and place in the centrifuge (the Babcock milk tester mentioned above). Place a suitable counterpoise[1] in the other receptacle of the centrifuge. Whirl for from one-half to one minute at a speed of about 1,000 revolutions per minute, that is with the handle turning about 100 revolutions per minute. Because of the air bubbles removed by whirling, the surface of the pulp will now be considerably below the top of the flask. Fill the flask and whirl in the centrifuge again. Repeat this filling and whirling until the flask is practically full of pulp after whirling. Ordinarily two or three separate whirlings are sufficient. Then add a few more drops of pulp so that the pulp comes above the top of the flask, and strike off flush with the top of the flask with a straight edge. Wash the

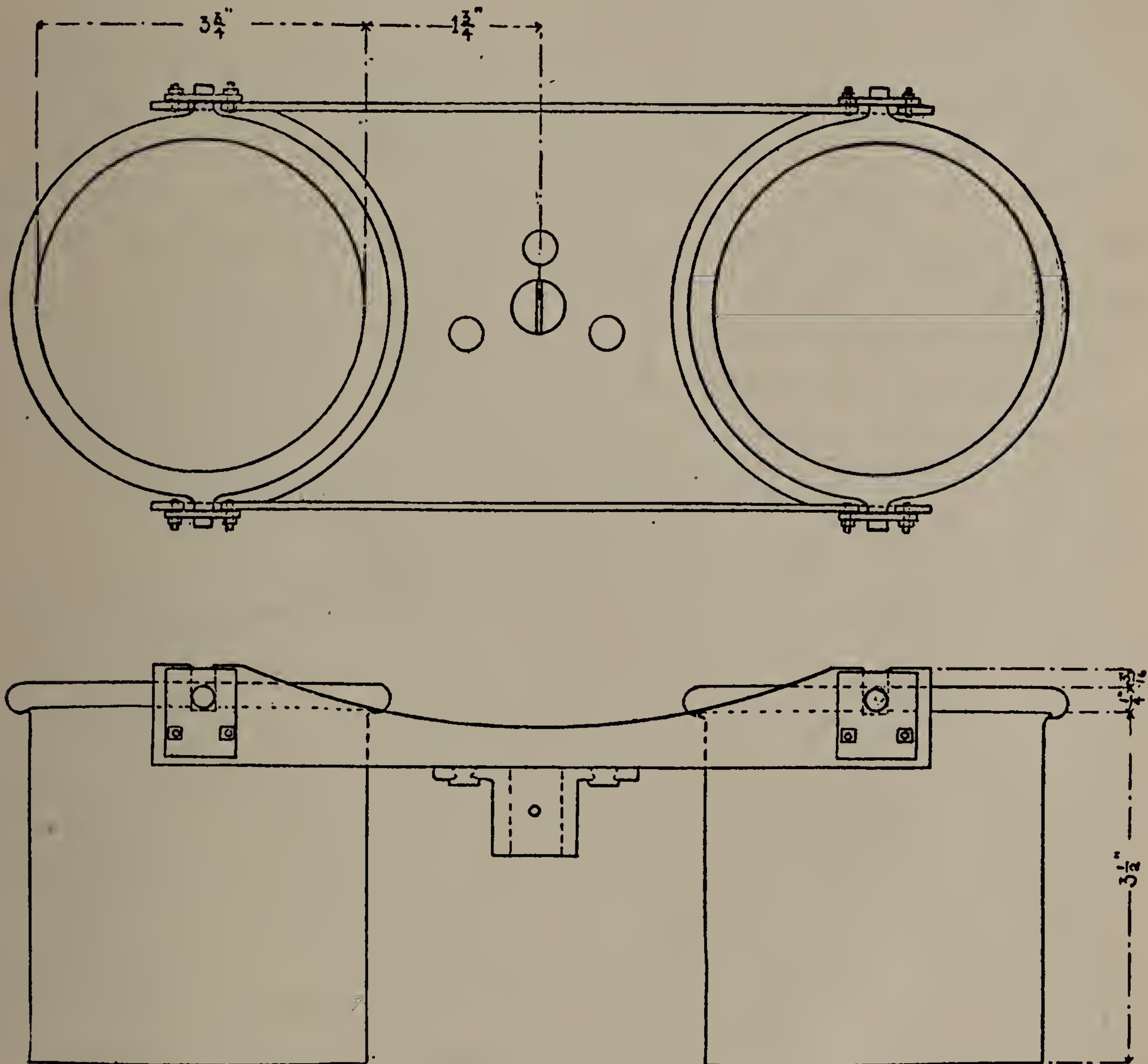

Fig. 3. Special Head and Flask Receptacles for Babcock Milk Tester.

outside of the flask, wipe dry, and weigh. Then read the specific gravity of the pulp from a table prepared, giving the weight of the flask full of pulp and the specific gravity of the pulp in parallel columns, or calculate the specific gravity as described below.

While the weight is being taken a thermometer may be placed in the pulp remaining in the can or dipper from which the flask was filled. If the temperature varies from 68° F. the specific gravity may be corrected by Table 8. In order to use this method the temperature of the pulp should not be

[1] This counterpoise may be prepared with a can or bottle weighted with some heavy material such as solder or shot, until it balances approximately the weight of the can full of pulp. The counterpoise, once prepared, may be left in the centrifuge.

below 50° F., or above 86° F.; otherwise, it should be warmed or cooled, as described above.

The method is accurate, simple, easily operated and fairly rapid. To calculate the specific gravity from the weights obtained, the weight of the clean, dry flask and of the water it contains at 68° F. are necessary. The weight of the clean, dry flask is then subtracted from the weight of the flask full of pulp to obtain the net weight of the pulp. This divided by the weight of the water the flask will contain at 68° F., gives the specific gravity.

A table can be constructed readily for each flask, which will give in parallel columns the weight of the flask full of pulp and the corresponding specific gravity. This greatly simplifies the determination, as it eliminates all calculation. When such a table is employed a balance giving actual weights is practically as convenient as one reading specific gravity directly. It has the very important advantage that the balance, weights, and flask may be tested from time to time.

In preparing such a table it is convenient first to draw a curve representing specific gravities of the pulp and corresponding weights of the flask full of pulp of various degrees of specific gravity. The table may then be constructed from the curve.

For instance, let us suppose that the flask weighs 56.00 grams and that when full of water at 68° F. (20° C.) it weighs 176.63 grams. The water contained at the temperature mentioned then weighs (176.63—56.00) 120.63 grams. Now the specific gravity of the pulp is its weight compared with the weight of an equal volume of water. Having the figures given above we can easily calculate the weight of the flask filled with pulp of any desired specific gravity. We may therefore calculate the weight of the flask plus pulp of two different specific gravities; mark those points on a sheet of coordinate paper with specific gravity of the pulp entered at the bottom and the weight of flask plus pulp at the side, and a straight line drawn through the two points mentioned gives us the weight of the flask when filled with pulp of any specific gravity.

For instance, if the flask mentioned above be filled with a pulp of the specific gravity of 1.03, the weight of the pulp is (120.63×1.03) 124.25 grams. This added to the weight of the flask (56.00 grams) gives us 180.25 grams. Similarly, if the flask be filled with pulp of 1.04 specific gravity the weight of the contents at 68° F. will be (120.63×1.04) 125.46 grams. This added to the weight of the flask (56.00 grams) gives 181.46 grams as the weight of flask plus

pulp. Now if a sheet of coordinate paper be prepared with specific gravities entered at the bottom and weight of flask plus pulp at the side, these points may be entered. This is done in Figure 4 and the

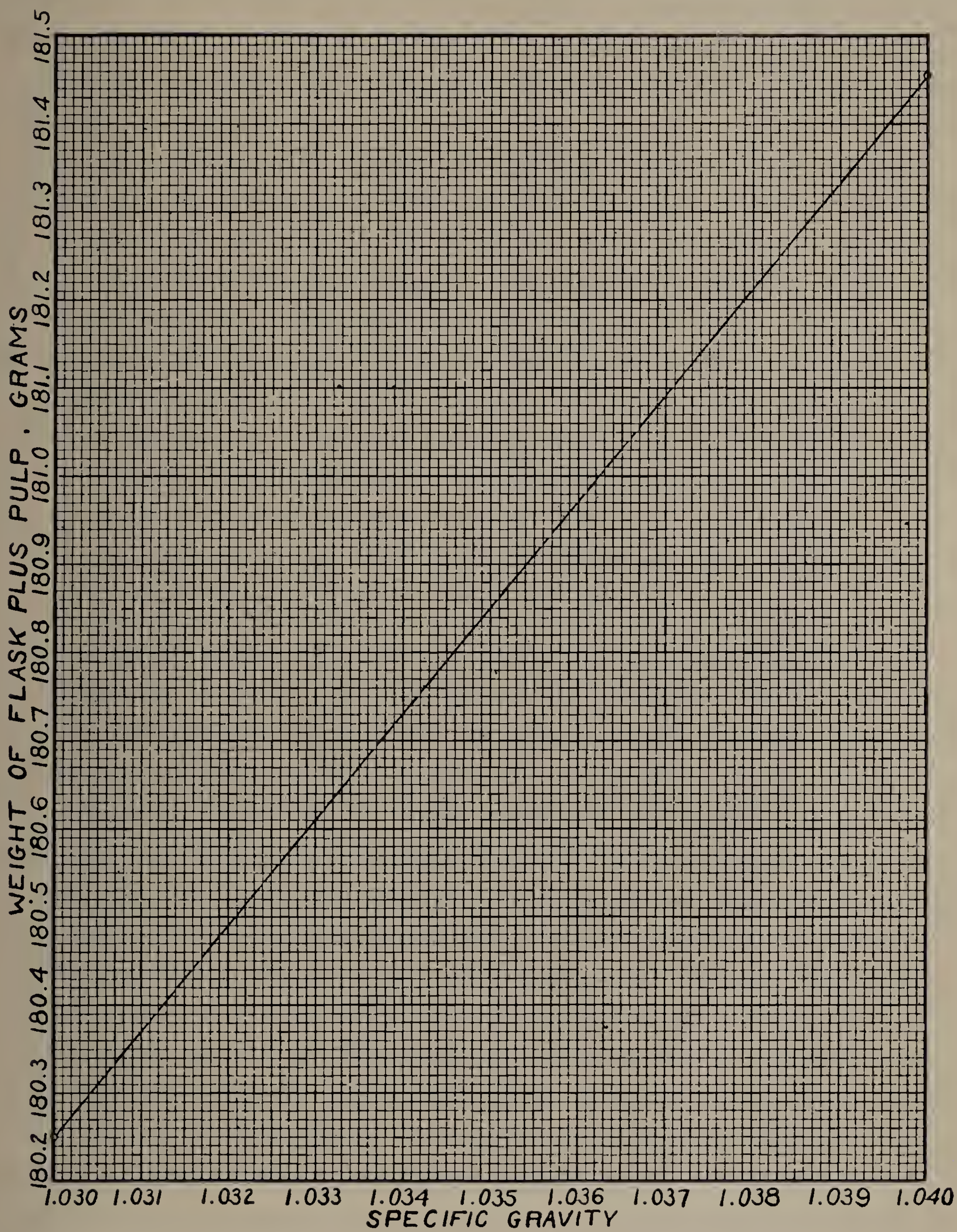

Fig. 4. Weight and Specific Gravity of Tomato Pulp.

two points mentioned are each indicated by a circle and are connected by a straight line. A table may be constructed from this line, giving the weights of flask plus pulp in one column and the corresponding specific gravity in another.

As an illustration of this there are given below a series of figures illustrating the beginning of the table that could be constructed from Figure 4. If a large sheet of coordinate paper be taken the line shown in Figure 4 may be extended so that a table may be constructed for pulp of all concentrations.

Weight of flask and pulp	Specific gravity
180.25	1.0300
180.31	1.0305
180.37	1.0310
180.43	1.0315
180.49	1.0320
180.55	1.0325
180.61	1.0330
180.67	1.0335

The highest degree of accuracy can be secured by filling the flask and making the weighing at exactly 68° F. This is obviously not practicable under factory conditions, however, and satisfactory results can be secured by taking the temperature of the pulp at the time of weighing and correcting for temperature by the use of Table 8. This table gives the correction to be added to the specific gravity when the pulp is taken at temperatures between 68° and 86° F., and the correction to be deducted from the specific gravity for temperatures between 55° and 68° F. As a matter of principle, correction factors should be avoided as far as practicable, and the smaller the correction factor the more accurate the results will be. This table will be found especially useful in determining the specific gravity of the partly concentrated pulp, as is directed on page 50.

As stated above, in determining specific gravity by this method it is advisable that the reading be made to the second place of decimals. For this purpose an assay pulp balance is suggested. An assay pulp balance carrying a maximum load of 300 grams is listed by dealers in chemical apparatus at $52.50. This balance may be obtained from dealers in chemical apparatus by designating it as "Assay pulp balance E. & A. No. 292, capacity 300 grams." The same balance, more

heavily built, and preferable for that reason, carrying a maximum capacity of 600 grams, is listed at $63.

A satisfactory set of weights, suitable for weighing a cup similar to that shown in Figure 1, may be obtained from any dealer in chemical apparatus by designating it as E. & A. No. 516, "Metric brass weights in wooden box, 200 grams to 1 centigram." This is listed at $5.50.

For convenience, all of the apparatus necessary for using this method of determining specific gravity is listed below. With the exception of the specific gravity flask this apparatus may be purchased of any dealer in chemical supplies. The specific gravity flasks have not heretofore been available except through this laboratory, which purchased a considerable quantity of them and supplied them to manufacturers of pulp as long as this supply lasted. At the urgent request of the writer, Eimer & Amend and Emil Greiner & Co., both of New York City, have finally stocked this item and stand ready to supply it to those wishing to secure it.

Specific gravity flask for tomato pulp, of Pyrex glass, 1½ x 6¼ inches (outside measurements), capacity about 125 cc.

Two-bottle Babcock milk tester, with 2 brass holders, E. & A. No. 1883.

Assay pulp balance, maximum load 300 grams, E. & A. No. 292.

Metric brass weights in wooden box, 200 grams to 1 centigram, E. & A. No. 516.

Chemical thermometer, 50 to 212° F.[1]

(b) COLD PULP WITHOUT CENTRIFUGING

A method frequently employed for determining the specific gravity of cold pulp is to fill the cup by pouring, strike off with a straight edge, wash the outside, dry and weigh. As ordinarily practiced, this determination is attended by considerable error. If the balance is arranged for reading specific gravity directly, weights should be at hand for determining the accuracy of the balance and the weight of the flask, and both should be checked from time to time. The pulp on being poured into the flask or cup carries with it air bubbles to such an extent as to materially reduce the weight. Attempts to remove these air bubbles without the use of a centrifuge have not been successful. This is shown in Table 7, in the column headed "Pouring cold and whirling by hand." The figures given in this column were obtained by weighing the sample after it had been whirled vigorously in the cup shown in Fig. 5 until air bubbles appeared to be eliminated.

[1] If it is preferred a chemical thermometer with Centigrade scale may be used having a range of from 0 to 100 degrees.

From 50 to 175 revolutions were given the cup in each of the determinations whose results are shown in this column. Even then it will be noted by comparison with Column 1 that the results are low. As the method is ordinarily practiced in the plant, without any attempt to remove the air bubbles by whirling, the results obtained are likely to be less accurate than those shown in the column just mentioned.

(c) SPECIFIC GRAVITY OF HOT PULP

Many manufacturers of tomato pulp control the concentration of their product by determining specific gravity when the evaporation is almost completed. They therefore desire the results at the earliest possible moment, and there is no attempt to cool the sample before determining specific gravity, although in that way much more accurate results could be obtained.

When necessary to use this method the hot pulp is poured into the specific gravity flask (Fig. 1 or Fig. 2) by means of a dipper until the flask overflows. The top is then "struck off" with a straight edge and the flask placed in a shallow basin of water and the pulp carefully washed from the outside. The temperature of the pulp remaining in the dipper is then determined by means of a chemical thermometer.

The flask is then dried with a towel, which operation is greatly facilitated by the heat of the pulp. The cooling of the contents of the flask causes contraction, so that after washing the flask is not entirely full. This should be disregarded, as it is desired to determine the weight of the amount of pulp that filled the flask originally. As soon as the outside of the flask is clean and dry the flask and contents are weighed.

The apparent specific gravity of the hot pulp is ascertained from the special table prepared for the flask according to the directions given on page 38, and the correction figure for the temperature of the pulp obtained from Table 6 is added. *For example,* this method when applied to a certain sample of hot pulp (without centrifuging) indicated a specific gravity of 0.9874. The temperature of the pulp was found to be 201° F. In Table 6 we find that the correction .0457 is equivalent to 201° F. Adding this to the apparent specific gravity given above, we have 0.9874 × 0.457 or 1.033 which is as nearly as we can determine from the hot pulp the specific gravity that would have been determined by examining the same sample after cooling by method (a). More accurate results can be obtained by working

with larger specific gravity flasks. For instance, the specific gravity cup shown in Figure 5 may be made of copper, and may readily be made larger than the glass flasks shown in Figures 1 and 2. All metal flasks will gradually change in weight, owing to the solution of metal by the hot tomato pulp, and their weight should therefore be checked from time to time.

Table 6.—*Corrections for Specific Gravity of Hot Pulp*

Temp. ° F.	Correction	Temp. ° F.	Correction	Temp. ° F.	Correction
190	.0401	198	.0441	206	.0482
191	.0406	199	.0447	207	.0487
192	.0411	200	.0452	208	.0492
193	.0416	201	.0457	209	.0498
194	.0421	202	.0462	210	.0504
195	.0426	203	.0466	211	.0510
196	.0431	204	.0472	212	.0515
197	.0436	205	.0477		

With a materially larger cup or flask (which should be of metal) a heavier balance and heavier weights should be used than suggested on page 40. In using a specific gravity cup similar to that shown in Figure 5 but holding about 1,000 grams of pulp an assay pulp balance with a capacity of 1,500 can be employed, or owing to the increased accuracy of the larger sample a less accurate and cheaper scale such as the "Howard trip scale," or better a box scale such as is listed as E. & A. 338, may be employed. In working with a cup of this size a set of weights ranging from 1000 grams to 1 centigram is necessary.

The determination of specific gravity in hot pulp is attended by considerable error. Even if the flask or cup be carried directly to the kettle, and filled as quickly as possible, the pulp is materially cooled in transferring, and by the time the surface is "struck off" sufficient contraction may occur to increase the weight of the contents of the flask and cause material error.

When a pail of hot pulp is carried to another room or building for the determination of specific gravity, the error caused by cooling may be increased. Again, notwithstanding the fact that the pulp is hot, enough air bubbles become incorporated into it in pouring into

the cup to make a considerable difference in the weight. These two errors counter balance each other to some extent, but it is impossible to control the manipulation with sufficient uniformity to secure satisfactory results.

The figures obtained in the second column of Table 7 (under the heading "Pouring at boiling temperature") show the error of this

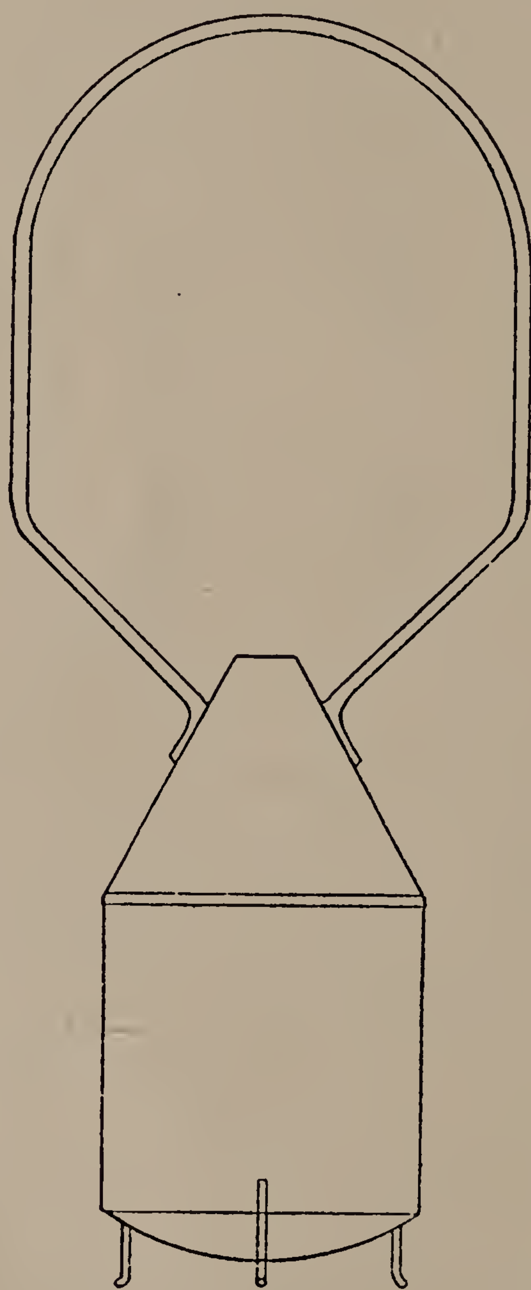

Fig. 5. Specific Gravity Cup for Hot Pulp.

method with carefully calibrated apparatus and working under the best conditions. By comparison with the first column, it will be noted that the results are always low, and that the difference between individual determinations is so great that a correction factor cannot be established. It should be borne in mind that these results were obtained by chemists. When the method is employed even by careful operators in the plant, still greater discrepancies may be expected.

TABLE 7.—*Comparison of Different Methods of Determining Specific Gravity* [1]

Sample Number	Specific gravity by different methods of filling cup or flask.			
	Centrifuging at 68° F.	Pouring cold and whirling by hand	Pouring at boiling temperature	Dipping at boiling temperature
1477	1.0610	....	1.0464	....
Do	1.0610	....	1.0449	....
Do	....	....	1.0600	....
1484	1.0423	1.0330	1.0380	....
1485	1.0347	....	1.0336	....
1483	1.0464	1.0437	1.042	....
Do	....	1.0420	1.0446	....
Do	....	1.0430	....	....
Do	....	1.0442	....	....
1482	1.0441	1.0416	1.0360	....
Do	1.0444	1.0419	1.0410	....
Do	1.0447	1.0424	1.0413	....
1481	1.0449	1.0410	1.040	....
Do	1.0449	1.0410	1.041	....
Do	....	1.0418	1.0397	....
1480	....	1.0430	1.036	....
Do	....	1.0420	1.040	....
Do	....	1.0429	1.044	....
Do	....	....	1.0407	....
1496	1.0340	1.0330	....	....
Do	1.0341	1.0326	....	....
Do	....	1.0326	....	....
Do	....	1.0346	....	1.0299
Do	....	1.0341	....	1.0303
Do	....	1.0341	....	1.0343
Do	....	....	....	1.033
1515	1.0351	....	....	1.036
Do	1.0352	....	....	1.035
1519	1.0380	....	....	1.0377
Do	....	....	....	1.0383
Do	....	....	....	1.0329
Do	....	....	....	1.0350
1521	1.0440	....	1.0410	1.0439
Do	....	....	1.0439	1.0448
1522	1.0500	....	1.0428	1.0493
Do	....	....	1.0455	1.0508
1524	1.0519	....	....	1.0504

TABLE 7.—*Comparison of Different Methods of Determining Specific Gravity*

Sample Number	Specific gravity by different methods of filling cup or flask.			
	Centrifuging at 68° F.	Pouring cold and whirling by hand	Pouring at boiling temperature	Dipping at boiling temperature
1524	....	....	....	1.0529
Do	....	....	....	1.0510
1526	1.0519	....	1.0472	1.0529
Do	....	....	1.0463	1.0525
1528	1.0519	....	1.0509	1.0514
Do	....	....	1.0485	1.0514
1530	1.0252	....	1.0281	1.0260
Do	....	....	....	1.0264
Do	....	....	....	1.0269
1531	1.0291	....	1.0312	1.0294
Do	....	....	....	1.0311
Do	....	....	....	1.0313

[1] Table 7 gives the results obtained in the determination of specific gravity of several samples of pulp by different methods. The specific gravity given in the first column under the head "Centrifuging at 68° F." has been proved to be correct by other analytical methods. It will be noted that where duplicate determinations are given in this column they agree with each other very closely. The errors in the other methods in determining specific gravity are shown in the remaining columns. It will be noted that the duplicates given in these columns vary materially from each other.

It should be stated that the results given under the heading "Pouring cold and whirling by hand" were obtained by much more careful work than is practicable in the factory. The flasks in which the determination was made were equipped with a bail, as shown in Fig. 5, page 44, and the samples were whirled by hand until air bubbles were eliminated as far as practicable by that method. The results in this column are therefore much more accurate than are obtained by the method as ordinarily practiced.

It was thought that better results might be secured by modifying the construction of a cup in such a manner as to permit it to be filled by dipping below the surface of the pulp in the kettle. A bail made of $\frac{3}{16}$-inch wire was, therefore, soldered to the opposite side of the cup (see Fig. 5). By means of the bail the cup was lowered into the kettle. After it was filled with the pulp the attempt was made to remove air bubbles by repeatedly giving the bail a quick twist or circular motion with a sudden stop. The cup was then brought quickly to the surface of the kettle and "struck off" with a straight edge, the outside of the cup and bail washed quickly with water, dried, and the cup and contents weighed.

In using this method the steam is turned off, and as soon as the

foam subsides the cup is sunk well below the surface of the pulp. At this time the heat in various portions of the kettle is of course uniform, by reason of the thorough mixture caused by the vigorous boiling. Owing to the large mass of rather viscous material, and the heat of the kettle itself, the contents of the kettle cool slowly, and even after 10 minutes the temperature does not decrease more than 1° F., except at the very surface of the pulp. As a result of several observations, it was found that a thermometer bulb held 3 inches below the surface of the pulp showed a lowering of temperature of not more than 1° F. in 10 minutes and a lowering of only 0.5° F. in from 5 to 7 minutes.

The bail employed was about 6½ inches wide and 8 inches long. There was some difficulty, owing to the pulp spattering on the hands of the operator because of the air escaping from the cup. This might be diminished by the use of a longer bail, or by wearing suitable gloves. When evaporating tanks are used it will probably be necessary to attach the bail to a stick or support of some kind. In addition to permitting this method of filling, the bail has the additional advantage that the cup full of pulp may be handled for washing and conveying to the balance much more conveniently and with less danger of spilling than with the handle on the side of the cup. Again, the bail does not heat when the cup is filled with hot pulp, and for that reason is easier to handle.

(d) HYDROMETER METHOD

Hydrometers are of little value in determining the specific gravity of tomato pulp. With cold pulp they cannot be used at all. With hot pulp a relatively slender hydrometer comes to rest and readings can be taken with more or less accuracy. The value of the reading is relative to the specific gravity of the pulp and varies with the shape of the hydrometer and with the character of the pulp. It is necessary therefore to obtain the relation between the reading of the hydrometer in the hot pulp and the specific gravity (obtained by an accurate method) of the same pulp cooled without evaporation. In the hands of a careful operator some manufacturers have found hydrometers (used with hot pulp) helpful in making pulp of uniform specific gravity.

The hydrometer gives much more accurate results with the filtrate of pulp. As shown on page 31, there is a direct relation between the

specific gravity of tomato pulp and of the liquor obtained by filtering or straining the same, so that when the specific gravity of the latter is known that of the former may be ascertained readily by means of a table. This method is peculiarly applicable to the examination of cyclone juice and light pulp from which the insoluble solids may be removed quickly by straining through a cloth, and it therefore affords the most rapid method that is available to the average factory for determining the specific gravity of cyclone juice.

In Table 8 are given a series of corrections making it possible to use this method at any temperature between 50 and 80° Fahrenheit. The more closely the readings are taken to 68° F. the more accurate the results. Moreover, when it is attempted to strain the insoluble solids from hot pulp or cyclone juice, considerable evaporation occurs, causing concentration of the product and producing an error in the results. When hot pulp is handled, therefore, it must be strained as quickly as possible, and more accurate results may be obtained if the pulp is cooled quickly before straining. This may be done by placing in a large can and stirring vigorously while the can stands in ice water, or shaking under water in a large flask.

There are several forms of hydrometer which may be used for determining the specific gravity of the filtrate. The ordinary specific gravity hydrometer is the most logical form to use, since it gives the specific gravity directly. Unfortunately, specific gravity hydrometers with the particular marking required for this work are not a stock article, and would, therefore, have to be made to order. For this reason they would be difficult to obtain and not easily replaced if broken.

The Brix hydrometer appears to solve the difficulty. This hydrometer has no direct relation to specific gravity, but Brix readings can, of course, be converted to the specific gravity readings by a table arranged in parallel columns. Table 9 gives the specific gravity of tomato pulp and the corresponding Brix reading of the filtrate. The Brix hydrometer gives directly the per cent of sugar in a solution of cane sugar, one degree Brix being equivalent to one per cent sugar at the temperature for which the hydrometer was calibrated. This fact and the ordinary purpose for which the instrument is manufactured are of no interest to us in this connection, however. The Brix hydrometer of the range desired for the examination of cyclone juice and pulp is a stock article and can be secured readily.

The instrument can be used with the same accuracy as the specific

gravity hydrometer, and the results obtained by it, after correcting for temperature by Table 8, are converted into terms of specific gravity by means of Table 9. The determination of the specific gravity of pulp by means of the hydrometer reading of the filtrate obtained from the pulp has several advantages over the ordinary method of weighing a measured quantity of the pulp. When applied to pulp manufactured from whole tomatoes, the method is reasonably accurate. It is also very rapid and the equipment required is inexpensive. This method is especially applicable to the examination of pulp manufactured from whole tomatoes. It is less applicable to trimming stock pulp, although even with that product the method will be of value, especially for the examination of cyclone juice for the purpose of controlling concentration. With pulp manufactured from trimming stock, the relation of the specific gravity of the pulp to the specific gravity of the filtrate obtained from it will vary according to the nature of the raw material used and also according to the method of manufacture. It seems probable, therefore, that after a manufacturer has determined this relation as applied to his own product, he may be able to use this method with reasonable accuracy even in connection with trimming stock pulp.

The method is adapted especially to the examination of cold pulp or cyclone juice.

The following apparatus is used in this method:

1 Brix hydrometer, graduated at 20.0° C., with a range of 1-10°, graduated in 1/10°.
1 Cylinder of heavy glass, lipped, height 12 inches, diameter 2 inches.
1 Chemical thermometer, graduated in Fahrenheit system up to 212° F.

Since this apparatus is likely to be broken, it is well for each plant that contemplates using the method to equip itself with at least two of each item mentioned above.

The Brix hydrometer mentioned above is suggested because it is a stock article handled by all dealers in chemical apparatus and can be secured quickly. It has the disadvantage that it is relatively large, and in order to use it the filtrate must be prepared in much larger quantity than would be required by a smaller hydrometer. By placing orders well in advance with dealers in chemical apparatus special hydrometers may be made with a bulb about one-half inch in diameter and with a total length of five or six inches. Such hydrometers could be used with a cylinder as small as one inch in diameter. They would require much less liquor than is necessary

for the Brix hydrometer and therefore would enable the analyst to obtain results much more quickly. In securing such hydrometers it would be well to order several at a time, since it would require several weeks to replace any that may be broken.

The details of the method are as follows:

Place a piece of cotton cloth of about the texture of ordinary glass toweling over a clean, dry container 10 or 12 inches in diameter or over a No. 10 can. Pour on the cloth a suitable amount of the pulp or cyclone juice to be examined, pick the cloth up by the corners and squeeze gently to separate the greater part of the insoluble solids. The strained liquid left in the vessel will be more or less turbid, according to the pressure exerted in squeezing. The amount of insoluble material producing this turbidity, however, is not usually sufficient to interfere with the examination of the product by means of a hydrometer. If, however, it is necessary to exert considerable pressure to get the amount of filtrate desired and the turbidity is therefore considerable it will be necessary to pass the liquor through a second filter, which, of course, may be done quickly.

Transfer this strained liquid, which for the sake of convenience we will designate as "filtrate," to the 2-inch cylinder described above, and lower the Brix hydrometer into it until the hydrometer floats. When the hydrometer becomes stationary, the reading on the stem is taken. In reading the hydrometer it will be noted that, owing to the meniscus, the liquid immediately at the stem rises one or two divisions above the general surface. The reading at the lowest point of the surface is desired. In reading the stem, therefore, allowance for the meniscus should be made and a reading recorded one or two divisions on the scale below the extreme height of the meniscus on the stem. The reading so obtained is recorded as the Brix hydrometer reading of the filtrate.

After determining the Brix reading of the filtrate from the tomato pulp, the corresponding specific gravity of the pulp may be obtained from Table 9. The result obtained by the method should be corrected to the temperature of 68° F., according to Table 8. If it is desired to use the reading of the filtrate from cyclone juice for the purpose of controlling the evaporation of tomato pulp, suitable directions are given below under "Evaporation to Specific Gravity Desired."

IMPORTANCE OF ACCURACY IN DETERMINING SPECIFIC GRAVITY

The description of the tables given in the following pages is intended for those operators who desire to take the trouble to obtain the specific gravity of the raw product. Where, as is often the case, the pulp is sold under definite specifications for specific gravity, the care necessary to make these observations with a considerable degree of accuracy will be found to be an economy.

If a product be shipped that is materially below the specific gravity stipulated, the manufacturer will of course be docked and the loss will be considerable. On the other hand, the specific gravity should not be materially above the specifications. The buyer, who is usually a manufacturer of ketchup, desires the pulp of the specific gravity stipulated, and a higher degree of concentration is therefore not a

mark of superiority in pulp intended for that purpose. Moreover, material increase in concentration above the specifications of the purchaser causes considerable loss by reason of reduced volume. For instance, 100 gallons of pulp with a specific gravity of 1.036 are equivalent to 103 gallons of a pulp with a specific gravity of 1.035. Again, 100 gallons of pulp with a specific gravity of 1.040 are equivalent to 114.7 gallons of pulp with a specific gravity of 1.035.

When these figures are considered with reference to the entire output of the season, it is apparent that the determination of the specific gravity of the final product is of considerable importance, and will warrant care and, if necessary, the employment of a man who is competent to do the work accurately.

This is well illustrated by an experience of one of the large pulp makers, who was selling pulp under specification of 1.035 specific gravity. Owing partly to an error in his specific gravity apparatus, he was actually turning out pulp of a specific gravity varying from 1.040 to 1.050. In other words, each 100 cases of pulp he delivered were equivalent to from 115 to 126 cases of pulp of 1.035 specific gravity. While this manufacturer was using the greater part of the pulp himself, he had contracted to sell a considerable amount of it, and all that was supplied before the error was noticed was sold at a loss, whereas after the error was discovered he supplied pulp well above the specifications of the buyer at a substantial profit. Even then his profit was not what it should have been. His output would have been 10 per cent greater than it was if the specific gravity of his product had just complied with his specifications.

Another manufacturer who sold his pulp under the specification of 1.035 specific gravity, received a complaint from one of the largest buyers of pulp in the country that the specific gravity was low. The manufacturer then examined samples, which he had retained in his possession, of the various runs, using the method described on page 41, under the head of "Specific gravity of cold pulp without centrifuging." Seventeen samples in all were examined, and he obtained an average specific gravity of 1.0276. The purchaser had reported a specific gravity of 1.0315—.0039 higher than that obtained by the maker. The manufacturer then brought duplicate samples to this laboratory and the specific gravity was determined in all of them by the method described on page 34, "After centrifuging to eliminate air bubbles."

While this work was being done the manufacturer himself desired

to check the mechanical centrifuge, and attempted to remove the air bubbles from the same samples by swinging the specific gravity cups by hand. He made a special effort to remove the air bubbles in this way, devoting nearly a day to the examination of the 17 samples. Notwithstanding his unusual care, his average specific gravity was 1.0318, while the centrifuge method gave 1.0328. It will be noted that the specific gravity as determined by the centrifuge method was .0013 higher than that obtained by the purchaser, though the latter used a more accurate method than has ordinarily been employed in this determination. This difference has ordinarily been regarded in the industry as insignificant. It is apparent that it is not negligible, however, when we consider that the difference in yield involved amounts to over 4.5 gallons in 100 gallons of pulp.

It is true that all these results are lower than the specifications for which this particular pulp was sold, but the incident illustrates the importance of an accurate determination of specific gravity.

EVAPORATION TO THE SPECIFIC GRAVITY DESIRED

Manufacturers of tomato pulp have considerable difficulty in securing a product of uniform concentration and in determining at what point to stop evaporation. Some manufacturers turn off the steam when it is believed that the concentration has gone far enough and make a hasty determination of specific gravity. If it is found that the concentration is not as great as is desired, heating is resumed for a time and the specific gravity again determined. Others make but one determination of specific gravity when it is believed that the desired concentration has been reached, and if it is found to be underconcentrated, continue the evaporation for a length of time which experience has indicated to be necessary. Neither of these methods of operating is satisfactory. They involve a great deal of work and the concentration of the product obtained is not sufficiently uniform. Moreover, the determination of specific gravity of hot pulp is very inaccurate (see p. 44).

A method of employing a gauge stick is believed to be simpler and more practicable.

Some manufacturers who desire to work with the simplest possible methods, even at the sacrifice of a high degree of control over the concentration of their products, measure the volume of cyclone juice introduced into the evaporating tank; and when it is believed that the concentration is sufficient, measure the depth of the evaporated prod-

uct in the tank, the steam being momentarily turned off for that purpose and the measurement being taken after the foam subsides. This method was outlined in detail in a trade paper article published from this laboratory in 1918. The method is somewhat inaccurate, because it is based on the measurement of cyclone juice as it flows from the cyclone and which therefore contains a large amount of air. This air materially increases the volume of the pulp and consequently the amount of finished pulp calculated from the volume of cyclone juice containing this air is greater than can actually be obtained. Some manufacturers of pulp have found the method practicable, however, by making a correction based on factory experience on the amount of pulp which the method indicates should result from the evaporation of each bath. This method also calls for the use of measuring tanks, which many manufacturers do not have and do not care to provide. The method is therefore not repeated here, but the laboratory has a number of reprints of the trade paper article which are available to any who desire more detailed information regarding the matter.

The following method has been found more accurate and more convenient than the one mentioned above. It has the special advantage that it is based on the examination of the cyclone juice after the juice has been heated to a sufficient extent to "break" the foam.

In using this method, the manner in which the cyclone juice is prepared is immaterial. The tomatoes may be broken by steam or mechanical breaker and may be cycloned hot or cold. The steam may be turned into the coils as soon as they are covered and the cyclone juice may run into the evaporating tank until the tank is filled.

Finally, when the last of the cyclone juice is added and the contents of the tank are boiling vigorously, the steam is momentarily turned off. The volume is then determined by means of a gauge stick and a sample is withdrawn, filtered and the specific gravity or degrees Brix determined as described on page 50. The extent to which evaporation must be continued to secure pulp of the desired specific gravity is determined by Table 9.

This table gives in the first four columns the specific gravity of the partially concentrated pulp taken from the evaporating tank, the per cent of solids of the same, the specific gravity of the filtrate and the Brix reading of the filtrate. In order to use the tables, it is only necessary to make use of one of these columns.

This method of operation can be simplified and more accurate re-

sults obtained by equipping each evaporating tank with a one-inch gage glass extending the full height of the tank. The gage glass should be open at the top and connected with the bottom of the tank by a pipe equipped with a valve. Before the tank is filled with cyclone juice the valve is turned off and the gage glass filled with water. Steam is turned on as soon as the pipes are covered and the foam is "broken" quickly without trouble that was experienced in heating the tank filled with cool pulp. The heat is continued while the tank is filled to the desired height with the pulp. The steam is then momentarily turned off and the valve at the top of the gage glass opened to permit the water in the gage glass to equalize in height with the partly concentrated pulp within the tank. The height of water in the gage glass is read by a scale attached, the sample of the pulp taken for examination and the steam again turned on.

There is ample time to determine the specific gravity of the sample of partly concentrated pulp and from its volume as obtained by the gage glass to calculate the volume to which the pulp should be evaporated to secure the desired specific gravity in the finished product. The specific gravity of the sample may be taken by any of the methods described in the chapter on "Determination of specific gravity." More accurate results can be obtained by pouring the sample of pulp as soon as it is taken into a large loosely stoppered flask and holding the flask with constant agitation in a tub of ice water until it is brought to about the temperature of the room.

Having determined the volume (when heated to the boiling point) of a batch of cyclone juice or of pulp at any stage of its manufacture and its specific gravity (at 68° F.), each of the last five columns of the table gives a factor by which the volume of the partially evaporated pulp may be multiplied to determine the volume of pulp of the specific gravity given at the top of the column. Since both measurements are taken at the boiling point the question of temperature need not be considered.

Illustration: Suppose that when the cyclone juice is all added to the tank the contents of which are vigorously boiling so that they are doubtless of uniform composition, the volume is found by the gauge stick to be 815 gallons. A sample of this partially evaporated pulp is withdrawn and filtered and the filtrate is found to have a Brix reading of 6.90. Let us suppose that the product is to be evaporated to a pulp having a specific gravity of 1.035 and the operator desires to know at what point to turn off the steam. By referring to Table 9 in the column headed by the figure 1.035, we find opposite the Brix reading 6.90 the factor .834. Multiplying the volume of the pulp (815 gallons) by this factor, we obtain 680 gallons. It follows, therefore, that the

TABLE 8.—*Corrections for Specific Gravity and Brix*[1] *Readings at Different Temperatures to 68 Degrees F. (20 Degrees C.)*

Corrections to be subtracted from specific gravity or degrees Brix.

Temperature		Corrections		Temperature		Corrections	
Deg. F.	Deg. C.	Sp. Gr.	Brix.	Deg. F.	Deg. C.	Sp. Gr.	Brix.
50	10.0	.0017	.38	59	15.0	.0010	.22
51	10.6	.0016	.36	60	15.6	.0009	.20
52	11.1	.0016	.35	61	16.1	.0009	.18
53	11.7	.0015	.33	62	16.7	.0008	.16
54	12.2	.0014	.31	63	17.2	.0007	.13
55	12.8	.0014	.30	64	17.8	.0006	.11
56	13.3	.0013	.28	65	18.3	.0004	.08
57	13.9	.0012	.26	66	18.9	.0003	.05
58	14.4	.0011	.24	67	19.4	.0002	.03

Corrections to be added to specific gravity or degrees Brix.

Temperature		Corrections		Temperature		Corrections	
Deg. F.	Deg. C.	Sp. Gr.	Brix.	Deg. F.	Deg. C.	Sp. Gr.	Brix.
69	20.6	.0002	.03	79	26.1	.0017	.35
70	21.1	.0003	.05	80	26.7	.0018	.39
71	21.7	.0004	.08	81	27.2	.0019	.42
72	22.2	.0006	.11	82	27.8	.0021	.46
73	22.8	.0007	.15	83	28.3	.0023	.49
74	23.3	.0009	.18	84	28.9	.0024	.54
75	23.9	.0011	.21	85	29.4	.0026	.58
76	24.4	.0012	.24	86	30.0	.0027	.62
77	25.0	.0013	.28	87	30.6	.0029	.66
78	25.6	.0015	.32	88	31.1	.0031	.70

[1] These temperature corrections are for a Brix instrument standardized for 20°C. There are Brix hydrometers on the market standardized for 17.5°C. Temperature corrections for a Brix hydrometer standardized at this temperature may be obtained by correcting to 20° by means of the above table (for instrument graduated at 20°C.) and adding to this corrected reading 0.12. For instance suppose the reading for a 17.5° instrument is 7.00 at 25°C. The correction from the above table will be .28 or a total of 7.28. Adding .12 to this gives a corrected reading of 7.40. If the reading is 7.00 at 15°C. the correction from the above table amounts to .22 (to be subtracted) giving 6.78. Adding 0.12 to this gives the corrected reading of 6.90.

TABLE 9.—*Equivalent Volumes of Pulp of Different Degrees of Concentration*

Tomato pulp		Filtrate from pulp		Factor by which to multiply volume of pulp of given specific gravity to ascertain volume of pulp with equivalent solid content and with specific gravity of				
Specific gravity at 68° F.	Per cent solids	Specific gravity at 68° F.	Degrees Brix at 68° F.	1.030	1.035	1.040	1.045	1.050
1.0125	2.79	1.0108	2.78	.384	.326	.283	.249	.223
1.0130	2.92	1.0113	2.89	.402	.342	.296	.261	.234
1.0135	3.05	1.0118	3.02	.420	.357	.310	.273	.244
1.0140	3.17	1.0123	3.14	.437	.372	.323	.285	.255
1.0145	3.30	1.0128	3.27	.455	.388	.336	.297	.265
1.0150	3.42	1.0133	3.40	.472	.401	.348	.306	.274
1.0155	3.54	1.0138	3.51	.489	.416	.361	.318	.284
1.0160	3.67	1.0143	3.65	.507	.431	.374	.329	.294
1.0165	3.79	1.0148	3.77	.524	.445	.387	.341	.304
1.0170	3.92	1.0153	3.90	.542	.460	.400	.352	.315
1.0175	4.05	1.0158	4.03	.560	.476	.413	.364	.325
1.0180	4.18	1.0163	4.15	.579	.491	.426	.375	.335
1.0185	4.30	1.0168	4.28	.596	.506	.440	.387	.346
1.0190	4.43	1.0173	4.40	.614	.521	.452	.399	.356
1.0195	4.56	1.0178	4.53	.632	.537	.466	.410	.367
1.0200	4.68	1.0182	4.63	.649	.551	.478	.421	.377
1.0205	4.81	1.0188	4.77	.667	.566	.491	.433	.387
1.0210	4.93	1.0192	4.87	.684	.581	.504	.444	.398
1.0215	5.05	1.0196	4.97	.701	.596	.517	.456	.407
1.0220	5.17	1.0201	5.10	.718	.610	.529	.467	.417
1.0225	5.30	1.0206	5.22	.737	.625	.543	.479	.428
1.0230	5.43	1.0211	5.35	.755	.641	.556	.490	.438
1.0235	5.55	1.0216	5.47	.772	.656	.569	.502	.448
1.0240	5.67	1.0220	5.57	.789	.671	.582	.513	.459
1.0245	5.80	1.0226	5.72	.808	.686	.595	.525	.469
1.0250	5.92	1.0230	5.82	.825	.701	.608	.536	.479
1.0255	6.04	1.0235	5.94	.842	.715	.620	.547	.489

TABLE 9.—*Equivalent Volumes of Pulp of Different Degrees of Concentration*—Continued

Tomato pulp		Filtrate from pulp		Factor by which to multiply volume of pulp of given specific gravity to ascertain volume of pulp with equivalent solid content and with specific gravity of				
Specific gravity at 68° F.	Per cent solids	Specific gravity at 68° F.	Degrees Brix at 68° F.	1.030	1.035	1.040	1.045	1.050
1.0260	6.16	1.0240	6.07	.859	.729	.633	.558	.499
1.0265	6.28	1.0244	6.17	.876	.744	.646	.569	.509
1.0270	6.40	1.0249	6.29	.894	.759	.658	.580	.519
1.0275	6.53	1.0254	6.43	.912	.775	.672	.592	.529
1.0280	6.65	1.0258	6.53	.930	.789	.685	.604	.539
1.0285	6.77	1.0263	6.65	.947	.804	.697	.615	.549
1.0290	6.90	1.0268	6.78	.965	.819	.711	.626	.560
1.0295	7.02	1.0273	6.90	.983	.834	.724	.638	.570
1.0300	7.14	1.0278	7.03	1.000	.849	.737	.649	.580
1.0305	7.26	1.0282	7.13	1.017	.864	.749	.660	.590
1.0310	7.38	1.0287	7.23	1.035	.878	.762	.672	.600
1.0315	7.50	1.0292	7.35	1.052	.893	.775	.683	.610
1.0320	7.63	1.0296	7.45	1.071	.908	.788	.695	.621
1.0325	7.75	1.0301	7.58	1.088	.924	.802	.706	.631
1.0330	7.88	1.0306	7.70	1.107	.939	.815	.718	.642
1.0335	8.00	1.0310	7.80	1.124	.954	.828	.730	.652
1.0340	8.12	1.0315	7.93	1.142	.970	.842	.742	.663
1.0345	8.25	1.0320	8.05	1.160	.985	.855	.753	.673
1.0350	8.37	1.0325	8.16	1.178	1.000	.868	.765	.684
1.0355	8.50	1.0330	8.27	1.197	1.016	.882	.777	.695
1.0360	8.62	1.0334	8.37	1.214	1.031	.895	.788	.705
1.0365	8.74	1.0339	8.50	1.232	1.046	.907	.800	.715
1.0370	8.86	1.0344	8.63	1.249	1.061	.920	.811	.725
1.0375	8.98	1.0349	8.75	1.267	1.076	.933	.823	.735
1.0380	9.10	1.0353	8.85	1.284	1.091	.947	.834	.746
1.0385	9.23	1.0358	8.97	1.303	1.106	.960	.846	.756
1.0390	9.35	1.0363	9.07	1.321	1.122	.974	.858	.767
1.0395	9.48	1.0368	9.20	1.340	1.138	.987	.870	.778
1.0400	9.60	1.0372	9.30	1.358	1.153	1.000	.881	.788
1.0405	9.73	1.0378	9.45	1.377	1.168	1.014	.893	.799

TABLE 9.—*Equivalent Volumes of Pulp of Different Degrees of Concentration*—Continued

Tomato pulp		Filtrate from pulp		Factor by which to multiply volume o pulp of given specific gravity to ascertain volume of pulp with equivalent solid content and with specific gravity of				
Specific gravity at 68° F.	Per cent solids	Specific gravity at 68° F.	Degrees Brix at 68° F.	1.030	1.035	1.040	1.045	1.050
1.0410	9.85	1.0383	9.57	1.394	1.184	1.027	.905	.809
1.0415	9.97	1.0387	9.67	1.412	1.199	1.041	.917	.820
1.0420	10.10	1.0393	9.80	1.431	1.215	1.054	.929	.830
1.0425	10.22	1.0397	9.90	1.449	1.230	1.067	.941	.841
1.0430	10.35	1.0402	10.03	1.468	1.246	1.081	.953	.851
1.0435	10.47	1.0406	10.13	1.486	1.261	1.094	.964	.862
1.0440	10.60	1.0411	10.25	1.505	1.277	1.108	.976	.873
1.0445	10.72	1.0416	10.36	1.523	1.293	1.122	.988	.884
1.0450	10.84	1.0420	10.45	1.540	1.308	1.135	1.000	.894
1.0455	10.96	1.0425	10.57	1.558	1.322	1.148	1.012	.904
1.0460	11.08	1.0429	10.67	1.576	1.338	1.161	1.023	.915
1.0465	11.20	1.0435	10.83	1.594	1.353	1.174	1.035	.925
1.0470	11.33	1.0440	10.93	1.613	1.369	1.188	1.047	.936
1.0475	11.45	1.0445	11.05	1.631	1.384	1.201	1.059	.946
1.0480	11.57	1.0449	11.15	1.649	1.400	1.215	1.071	.957
1.0485	11.70	1.0454	11.27	1.668	1.416	1.229	1.083	.968
1.0490	11.82	1.0459	11.40	1.686	1.432	1.243	1.095	.979
1.0495	11.95	1.0465	11.53	1.705	1.449	1.256	1.107	.990
1.0500	12.07	1.0468	11.60	1.724	1.464	1.270	1.119	1.000
1.0505	12.20	1.0474	11.75	1.743	1.479	1.284	1.131	1.011
1.0510	12.32	1.0478	11.84	1.761	1.495	1.298	1.144	1.022
1.0515	12.45	1.0482	11.93	1.780	1.511	1.311	1.156	1.033
1.0520	12.57	1.0488	12.07	1.797	1.526	1.325	1.167	1.043
1.0525	12.69	1.0492	12.17	1.816	1.542	1.338	1.179	1.054
1.0530	12.81	1.0497	12.30	1.834	1.557	1.351	1.191	1.065
1.0535	12.93	1.0502	12.40	1.852	1.572	1.364	1.203	1.076
1.0540	13.05	1.0506	12.50	1.870	1.588	1.378	1.215	1.086
1.0545	13.18	1.0512	12.65	1.890	1.604	1.392	1.227	1.097
1.0550	13.30	1.0516	12.74	1.908	1.620	1.405	1.239	1.107
1.0555	13.42	1.0520	12.83	1.926	1.635	1.419	1.250	1.118
1.0560	13.55	1.0525	12.95	1.945	1.651	1.433	1.263	1.129
1.0565	13.67	1.0529	13.05	1.964	1.667	1.447	1.275	1.140
1.0570	13.80	1.0534	13.16	1.983	1.684	1.461	1.288	1.151

TABLE 10.—*Specific Gravity and Solids of Tomato Pulp*[1]

Specific gravity at 68° F.	Per cent solids *in vacuo* at 70°C.	Specific gravity at 68° F.	Per cent solids *in vacuo* at 70° C.	Specific gravity at 68° F.	Per cent solids *in vacuo* at 70° C.	Specific gravity at 68° F.	Per cent solids *in vacuo* at 70° C.
1.0145	3.30	1.0320	7.63	1.0495	11.95	1.0730	17.76
1.0150	3.42	1.0325	7.75	1.0500	12.07	1.0740	18.00
1.0155	3.55	1.0330	7.88	1.0505	12.20	1.0750	18.25
1.0160	3.67	1.0335	8.00	1.0510	12.32	1.0760	18.50
1.0165	3.80	1.0340	8.12	1.0515	12.45	1.0770	18.75
1.0170	3.92	1.0345	8.25	1.0520	12.57	1.0780	18.99
1.0175	4.05	1.0350	8.37	1.0525	12.69	1.0790	19.24
1.0180	4.18	1.0355	8.50	1.0530	12.81	1.0800	19.48
1.0185	4.30	1.0360	8.62	1.0535	12.93	1.0810	19.72
1.0190	4.43	1.0365	8.74	1.0540	13.05	1.0820	19.97
1.0195	4.56	1.0370	8.86	1.0545	13.18	1.0830	20.22
1.0200	4.68	1.0375	8.98	1.0550	13.30	1.0840	20.47
1.0205	4.81	1.0380	9.10	1.0555	13.42	1.0850	20.72
1.0210	4.93	1.0385	9.23	1.0560	13.55	1.0860	20.96
1.0215	5.05	1.0390	9.35	1.0565	13.67	1.0870	21.21
1.0220	5.17	1.0395	9.48	1.0570	13.80	1.0880	21.46
1.0225	5.30	1.0400	9.60	1.0575	13.92	1.0890	21.70
1.0230	5.43	1.0405	9.73	1.0580	14.05	1.0900	21.95
1.0235	5.55	1.0410	9.85	1.0585	14.17	1.0910	22.20
1.0240	5.67	1.0415	9.97	1.0590	14.29	1.0920	22.45
1.0245	5.80	1.0420	10.10	1.0595	14.42	1.0930	22.70
1.0250	5.92	1.0425	10.22	1.0600	14.54	1.0940	22.94
1.0255	6.04	1.0430	10.35	1.0605	14.67	1.0950	23.18
1.0260	6.16	1.0435	10.47	1.0610	14.79	1.0960	23.43
1.0265	6.28	1.0440	10.60	1.0620	15.03	1.0970	23.68
1.0270	6.40	1.0445	10.72	1.0630	15.27	1.0980	23.93
1.0275	6.53	1.0450	10.84	1.0640	15.52	1.0990	24.18
1.0280	6.65	1.0455	10.96	1.0650	15.77	1.1000	24.43
1.0285	6.77	1.0460	11.08	1.0660	16.02	1.1010	24.67
1.0290	6.90	1.0465	11.20	1.0670	16.27	1.1020	24.92
1.0295	7.02	1.0470	11.33	1.0680	16.52	1.1030	25.18
1.0300	7.14	1.0475	11.45	1.0690	16.77	1.1040	25.42
1.0305	7.26	1.0480	11.57	1.0700	17.02	1.1050	25.67
1.0310	7.38	1.0485	11.70	1.0710	17.27	1.1060	25.91
1.0315	7.50	1.0490	11.82	1.0720	17.51	1.1070	26.16

[1] This table gives the per cent of total solids contained by pulp of different specific gravities varying from unconcentrated pulp as it comes from the cyclone to the highly concentrated product.

steam should be turned off when the evaporation has reached such a point that the gauge stick shows the volume of pulp to be 680 gallons.

Table 9 may be used in the same way for calculating the volume of any pulp, hot or cold, of any specified specific gravity equivalent to a certain volume of pulp of any other stated specific gravity when held at the same temperature. For instance, the illustration given above serves equally well to illustrate how the relative value of two finished pulps of different specific gravities may be calculated. It also shows directly the relative value (based on tomato solids alone) of the same volume of two pulps of different gravity.

Illustration: Suppose a shipment contains 1,000 cases of No. 10 cans of pulp thought to have a specific gravity of 1.040 but found on examination to have a specific gravity of 1.0365. What is the value of of the pulp in comparison with pulp of specific gravity of 1.040? Turning in Table 9 to the figure 1.0365 in the left-hand column we follow the horizontal line containing that figure to the column headed by specific gravity 1.040. Here we find that .907 is the factor by which to multiply the volume of pulp of a specific gravity 1.0365 to obtain the equivalent volume of pulp of specific gravity 1.040. The answer to our question therefore is $1000 \times .907 = 907$. In other words pulp of a gravity of 1.0365 judged by the tomato solids it contains, has 90.7 per cent of the value of pulp of the gravity of 1.040.

Table 9 is based on the results obtained from a series of samples of whole tomato pulp and cyclone juice varying in specific gravity from 1.02 to 1.05. The table was extended by calculation to give corresponding values for more dilute cyclone juices and more concentrated products. The lower portion of the table has been repeatedly confirmed by results obtained in the examination of cyclone juice and pulp, but the figures in the higher portion of the table are based on calculation from lower concentrations.

This table is only applicable to pulp to which no other substance, such as salt, has been added. Salt if present to the extent of more than 0.25 per cent can be recognized by the taste. The amount of salt, when any has been added, may be determined by the method given on page 33 and the specific gravity corrected by subtracting from the apparent specific gravity 0.007 for each per cent of salt present. This gives the specific gravity of the salt-free pulp and the corresponding per cent of solids may be obtained from Table 9.

TOMATO KETCHUP

Ketchup is defined in the Federal food standards as the clean, sound product made from properly prepared pulp of clean, sound, fresh, ripe tomatoes, with spices, and with or without sugar and vinegar.

The solid matter, or total solids, in ketchup varies from less than 12 per cent to over 37 per cent. This means that the product varies from a substance having barely sufficient tomato added to give color and taste, to a rich, heavy tomato ketchup. The variation of total solids in any one brand is, of course, less, but large differences are not unusual. Three bottles of one brand showed a solids content varying from 12 per cent to 16 per cent, and seven of another brand varied from 32 per cent to 37.2 per cent.

The amount of solids in a non-preservative ketchup should be not materially less than 28 per cent. It is necessary to have a rather high solid content for ketchup of this kind, so that it may keep after being opened on the consumer's table.

The variation in the insoluble solids is comparable to that in the total solids. The values for a number of samples examined in this laboratory ranged from .9 per cent to 2.3 per cent. As the insoluble solids come from the tomato pulp the amount of insoluble solids is to that extent an indication of the amount of tomato pulp used in the manufacture of the ketchup from whole tomato pulp. The consistency of the ketchup is dependent chiefly on the amount of insoluble tomato solids present.

The ash usually varies from 2 per cent to 4 per cent, owing to the different amounts of salt, which varies in general from 1½ to 3 per cent.

The acidity ranges from .4 to 2.3 per cent. The acidity is one of the most important factors in preventing the growth of bacteria and yeasts in the ketchup after being opened. In order to secure the best results the ketchup should have an acidity of over 1 per cent (expressed as acetic acid) and an acidity of 1.25 per cent or higher adds to the keeping quality of the ketchup after the bottle is opened. An increase in acidity will necessarily require an increase in the amount of sugar in order to secure the proper flavor; or, vice versa, an increase in the sugar will necessitate an increase in acidity. In

some ketchups about one-half of the acidity is due to the citric acid of the tomatoes and the remainder to the vinegar added in manufacture. With ketchups of exceptionally high acidity, the proportion of citric acid to total acid may be much less than this. There may be considerable difference in the acidity in ketchup of the same brand due to variations in manufacture.

The sugar present in the ketchup is derived both from the pulp and from the added sugar. In ketchup ranging from 12 to 30 per cent total solids, from 9 to 22 per cent of the solids may consist of sugars.

METHODS OF MANUFACTURE

Ketchup may be prepared either from the fresh tomatoes, or from pulp. The most common practice is to prepare it from fresh tomatoes, although some manufacturers prefer to make ketchup during the winter, when they are not so busy with other products, and therefore use pulp. Presuming that the same quality of stock is used and the same care used in manufacture, there are some advantages in making ketchup from fresh tomatoes. The pulp loses some of its color by bleaching, and a ketchup made from pulp is naturally subjected to more heating than that made from fresh tomatoes.

In the manufacture of ketchup the fresh tomatoes may be broken by steam or by the use of a mechanical breaker. Both methods have their advantages, some preferring the one method, some the other.

In securing good quality in ketchup the same factors must be considered as in the making of pulp. These factors are care in manufacture and the use of a raw product of good color and quality. For discussion of these points in regard to pulp, see page 7.

The constituents used in the manufacture of ketchup in addition to the tomatoes are sugar, vinegar, salt, onions and spices. The sugar generally used is granulated cane or beet sugar. Some of the lower grades of cane sugar may be used satisfactorily. The terms used to designate grades of sugar below granulated do not always give a correct idea of the purity of the sugar and in buying such grades it is best to have samples submitted and have analyses made for sugar content.

The vinegar generally used is 100-grain distilled vinegar.

The salt used is of the grade known as dairy salt.

A variety of spices is used in the manufacture of ketchup. Among these are cinnamon, cassia, cloves, all-spice, pepper, cayenne pepper,

ginger, mustard and paprika. Spices may be used either in the form of whole spices, ground spices or volatile spice oils. Whole spices are thought by some to produce a better flavor. Ground spices, when used, should be secured from a reputable manufacturer, as there is a possibility of adulteration or use of low-grade material in ground products. Volatile spice oils are used to some extent, especially of spices containing large amounts of tannin, where there is liability of discoloration due to the formation of iron tannate during the manufacture of the ketchup. Acetic acid extracts of spices are also used to a limited extent.

The sugar may be added at any time during the making of the ketchup, but is preferably added during the latter part of the cooking. There is less danger of scorching if added at this time. It should be added gradually and scattered over the surface of the cooking ketchup so that it may go into solution more readily.

Vinegar is always added a few minutes before finishing. The acetic acid of the vinegar is volatile, and a large portion of it will be driven off with steam if added at the beginning of the cooking.

Salt may be added at any time during the cooking, but it is best to add it sufficiently soon so that it will be dissolved and thoroughly mixed with the product.

The onions should be added chopped at the beginning of the cook.

Spices, either whole or ground, are generally placed in a bag and added at the beginning of the cook. If the volatile oils are used, they should be added shortly before finishing the ketchup, as otherwise a large amount of them may be carried off with the steam.

FACTORY CONTROL OF THE COMPOSITION OF KETCHUP

Ketchup of uniform color, consistency and taste can be produced only by controlling the quality and quantity of its constituents. Therefore, any satisfactory method of control necessitates the determination of the solids in the batch of cyclone juice before sugar, salt, vinegar and spices are added. Control, based solely on uniform specific gravity of the finished product, assures only that the specific gravity is uniform; it does not assure uniformity in consistency, sweetness, acidity, or in any other characteristic of the product.

Since, under any specific procedure in a factory, the distinctive tomato flavor and the consistency of the finished product depend en-

tirely on the tomato solids, and since about half the final acidity and sugar content is derived from the same source, the control of the tomato solid content is especially important.

Fortunately the solids in cyclone juice have a fairly uniform composition. The ratio of total solids to insoluble solids is fairly constant, likewise the ratio of sugar to acid. The sugar in cyclone juice varies from about 42 per cent to 54 per cent of the total solids, averaging about 50 per cent.

As the consistency or body of ketchup is due chiefly to the tomato solids, the amount of evaporation necessary to secure ketchup of the desired consistency from a known volume of pulp measured at the boiling temperature and of known Brix or specific gravity can be determined from Table 9, page 56. For instance, if the volume of the boiling pulp is 800 gallons and the corrected Brix reading of the filtrate is 5.10, it is found from Table 9 that it will be necessary to evaporate to 423 gallons to secure a ketchup of approximately the consistency of 1.040 pulp, to 374 gallons for a consistency comparable to 1.045 pulp, and to 334 gallons for a consistency comparable to 1.050 pulp. This evaporation is carried out, of course, with the addition of the necessary ingredients for the making of ketchup. The amount of these ingredients can be varied in order to secure ketchup of the desired flavor.

After having once decided on the amount of ingredients to be used, the manufacture may be standardized. Supposing for instance on evaporating 800 gallons of partly concentrated pulp of Brix of filtrate (5.10) to approximately 334 gallons (calculated from the 1.050 column in Table 9) it has been found that the use of 301 pounds of sugar, 26.7 gallons of 100 grain vinegar, 66.8 pounds of salt and 50.2 pounds of onions together with spices gives ketchup of the flavor desired. Dividing the amount of each ingredient by 334, it is found that each gallon of finished ketchup contains .9 pound of added sugar, .2 pound of salt, .15 pound of onions, and about 10 ounces of vinegar. After having determined the amount of each ingredient per gallon of finished ketchup, it is easy to make a table giving the amount of ingredients necessary for a given volume of cyclone juice or concentrated pulp of any gravity. In Table 11 such calculations are made. This table is based on securing a ketchup having the consistency of 1.050 pulp and starting with 800 gallons of boiling pulp of specific gravity 1.0220 (Brix reading of filtrate 5.10). Some manufacturers may desire to base the amount of ingredients on 100 gallons or mul-

TABLE 11.—*Manufacture of Ketchup. Quantity of Constituents to be Added to 800 Gallons of Boiling, Partly Concentrated Pulp*

Specific gravity of pulp at 68° F.	Filtrate from pulp		Volume of finished ketchup	Added constituents			
	Degrees Brix at 68° F.	Specific gravity at 68° F.		Sugar	100-grain vinegar	Salt	Onions
			Gals.	*Lbs.*	*Gals.*	*Lbs.*	*Lbs.*
1.0154	3.50	1.0137	226.0	203	18.1	45.2	33.0
1.0158	3.60	1.0141	232.0	209	18.5	46.4	34.8
1.0162	3.70	1.0145	239.0	215	19.1	47.8	35.9
1.0166	3.80	1.0149	245.0	221	19.6	49.0	36.8
1.0170	3.90	1.0153	252.0	227	20.2	50.2	37.8
1.0174	4.00	1.0157	258.0	232	20.6	51.8	38.7
1.0178	4.10	1.0161	265.0	239	21.2	53.0	39.8
1.0182	4.20	1.0165	272.0	245	21.7	54.4	40.8
1.0186	4.30	1.0169	278.0	250	22.2	55.6	41.7
1.0190	4.40	1.0173	285.0	257	22.8	57.0	42.8
1.0194	4.50	1.0177	292.0	263	23.4	58.4	43.8
1.0199	4.60	1.0181	299.0	269	23.9	59.8	44.9
1.0202	4.70	1.0185	306.0	275	24.5	61.2	45.9
1.0206	4.80	1.0189	313.0	282	25.0	62.6	47.0
1.0211	4.90	1.0193	320.0	288	25.6	64.0	48.0
1.0216	5.00	1.0197	327.0	294	26.2	65.4	49.1
1.0220	5.10	1.0201	334.0	301	26.7	66.8	50.2
1.0224	5.20	1.0205	341.0	307	27.3	68.2	51.2
1.0228	5.30	1.0209	347.0	312	27.8	69.4	52.1
1.0232	5.40	1.0213	354.0	319	28.3	70.8	53.2
1.0236	5.50	1.0217	361.0	324	28.9	72.2	54.2
1.0240	5.60	1.0221	368.0	331	29.4	73.6	55.2
1.0244	5.70	1.0225	374.0	337	29.9	74.8	56.2
1.0249	5.80	1.0229	381.0	343	30.5	76.2	57.2
1.0253	5.90	1.0233	388.0	349	31.0	77.6	58.2
1.0257	6.00	1.0237	395.0	356	31.6	79.0	59.3
1.0261	6.10	1.0241	402.0	362	32.1	80.4	60.4
1.0266	6.20	1.0245	409.0	368	32.7	81.8	61.4
1.0271	6.30	1.0249	416.0	374	33.3	83.2	62.5
1.0275	6.40	1.0253	422.0	380	33.8	84.4	63.4

Table 11.—*Manufacture of Ketchup. Quantity of Constituents to be Added to 800 Gallons of Boiling, Partly Concentrated Pulp*—Continued

Specific gravity of pulp at 68° F.	Filtrate from pulp		Volume of finished ketchup	Added constituents			
	Degrees Brix at 68° F.	Specific gravity at 68° F.		Sugar	100-grain vinegar	Salt	Onions
			Gals.	*Lbs.*	*Gals.*	*Lbs.*	*Lbs.*
1.0279	6.50	1.0257	429.0	386	34.3	85.8	64.4
1.0283	6.60	1.0261	436.0	392	34.9	87.2	65.4
1.0287	6.70	1.0265	443.0	399	35.4	88.6	66.5
1.0291	6.80	1.0270	450.0	405	36.0	90.0	67.5
1.0295	6.90	1.0274	457.0	411	36.6	91.4	68.6
1.0299	7.00	1.0278	464.0	418	37.1	92.8	69.6
1.0304	7.10	1.0282	471.0	424	37.7	94.2	70.7
1.0309	7.20	1.0286	478.0	430	38.2	95.7	71.8
1.0313	7.30	1.0290	485.0	437	38.8	97.1	72.8
1.0318	7.40	1.0294	492.0	443	39.4	98.5	73.8
1.0322	7.50	1.0298	499.0	449	39.9	99.9	74.9
1.0326	7.60	1.0302	506.0	455	40.5	101.3	76.0
1.0330	7.70	1.0306	513.0	462	41.1	102.7	77.0
1.0335	7.80	1.0310	521.0	469	41.7	104.2	78.2
1.0339	7.90	1.0315	529.0	476	42.3	105.8	79.4
1.0343	8.00	1.0319	536.0	482	42.9	107.2	80.4
1.0347	8.10	1.0323	543.0	489	43.5	108.6	81.5
1.0352	8.20	1.0327	550.0	495	44.0	110.0	82.6
1.0356	8.30	1.0331	557.0	501	44.5	111.4	83.6
1.0361	8.40	1.0335	564.0	508	45.1	112.8	84.7
1.0365	8.50	1.0339	571.0	514	45.7	114.2	85.7
1.0369	8.60	1.0343	578.0	520	46.2	115.6	86.8
1.0374	8.70	1.0348	585.0	527	46.8	117.0	87.8
1.0379	8.80	1.0352	592.0	533	47.4	118.4	88.8
1.0383	8.90	1.0356	600.0	540	48.0	119.0	90.0

tiple of 100 gallons of finished ketchup. This may be done by first making out a table similar to 9 and then calculating the amount of pulp and other ingredients for 100 gallons of ketchup. This would, however, involve considerable work as unless the pulp used had a constant specific gravity, a calculation of the quantity of each ingredient would have to be made for the volume of pulp for each batch.

The use of Table 11 gives a ketchup of medium concentration. Using this as a basis the manufacturer can decide the extent to which he should evaporate to secure a ketchup of the consistency desired and modify the table accordingly.

Final concentration of the ketchup is controlled in the same manner as for pulp, either by a gauged tank or by specific gravity determination. If we start, therefore, with a given volume of partially concentrated cyclone juice and determine the solids present, we can in every case quickly ascertain from the appropriate table the number of gallons of finished product we should obtain, and the gauge stick or attached gauge glass will indicate when to stop evaporation in the tank. One advantage of measuring the original volume at the boiling temperature is that no temperature corrections are necessary, as both the initial and final temperature measurements are approximately the same.

The final concentration may be controlled, as stated above, by determining the specific gravity of the finished product by one of the methods given under pulp (see page 33 and following). The determination of specific gravity at this point will probably give more accurate results than the use of a gauge stick, and is to be recommended for use with the finished product, provided the added constituents have been standardized. The method described on page 42 for determining the specific gravity of hot tomato pulp, may be used for obtaining the per cent of solids in the boiling cyclone juice in place of the Brix spindle reading on the filtrate.

Table 11 for controlling the concentration of finished ketchup is based on the idea that there shall be a definite volume of partly concentrated pulp in the tank when the inflow of cyclone juice is stopped and the sample is taken for analysis. In this respect, this method of controlling the concentration of ketchup varies from the method described on page 54 for the control of the concentration of tomato pulp. It is sometimes convenient to secure this definite volume by filling the tank to a greater height than is desired and evaporating until the desired volume is secured. When this point is reached the sample of pulp is taken for specific gravity and steam is again turned on the tank.

The Abbé refractometer may also be used for controlling the final concentration of the ketchup. This provides a very simple and quick method for determining the percentage of solids. It requires but a few drops of the filtered liquor from the ketchup to make the deter-

mination. The reading may be taken and the calculation made in one or two minutes' time by use of Tables 13 and 14.

The table for calculating the solids from the refractometer reading is Geerlig's table for dry substance in sugar-house products, and is taken from the Methods of the Association of Official Agricultural Chemists, 1919. The entire table is not given but only the range over which it might possibly be desired to use it in the control of the manufacture of ketchup.

The results by this method are only approximate, but are sufficiently accurate for manufacturing control. Table 12 gives a comparison of the solids obtained by drying in vacuum at 70° C. with results obtained by the refractometer.

Table 12.—*Solids in Ketchup Obtained by Drying in Vacuum at 70° C. and by Abbé Refractometer from Geerlig's Table*

Solids in tomato ketchup	
By drying in vacuum at 70° C.	By Abbé refractometor
Per cent	*Per cent*
29.5	29.0
30.0	29.4
32.8	32.4
28.0	27.9
22.0	21.8
27.7	28.0

There are several errors in this determination which partially compensate for each other and give results fairly comparable with those obtained by drying. The refractometer of course determines only soluble constituents. Since salt gives a higher refractive reading than the same per cent of sugar, and since tomato solids give a higher refractive reading than the same percentage of sugar, and since any acetic acid of the vinegar is also read as solids on the refractometer, the total increase in reading due to these different factors nearly compensates for the insoluble solids of the ketchup.

The variation of the per cent of solids as obtained by the refractometer from that obtained by drying will depend somewhat on the composition of the ketchup and in using the refractometer it is ad-

visable to also determine the solids by drying on a few samples to obtain the relation between the two figures for that particular ketchup.

TABLE 13.—*Refractive Index and Per Cent Solids in Tomato Ketchup*[1]

Refractive index	Per cent solids	Decimals to be added for fractional readings	Refractive index	Per cent solids	Decimals to be added for fractional readings
1.3484	11	0.0001=0.05	1.3746	27	0.0001=0.05
1.3500	12	0.0002=0.1	1.3764	28	0.0002=0.1
1.3516	13	0.0003=0.2	1.3782	29	0.0003=0.15
1.3530	14	0.0004=0.25	1.3800	30	0.0004=0.2
1.3546	15	0.0005=0.3	1.3818	31	0.0005=0.25
1.3562	16	0.0006=0.4	1.3836	32	0.0006=0.3
1.3578	17	0.0007=0.45	1.3854	33	0.0007=0.35
1.3594	18	0.0008=0.5	1.3872	34	0.0008=0.4
1.3611	19	0.0009=0.6	1.3890	35	0.0009=0.45
1.3627	20	0.0010=0.65	1.3909	36	0.0010=0.5
1.3644	21	0.0011=0.7	1.3928	37	0.0011=0.55
1.3661	22	0.0012=0.75	1.3947	38	0.0012=0.6
1.3678	23	0.0013=0.8	1.3966	39	0.0013=0.65
1.3695	24	0.0014=0.85	1.3984	40	0.0014=0.7
1.3712	25	0.0015=0.9	1.4003	41	0.0015=0.75
1.3729	26	0.0016=0.95			0.0016=0.8
					0.0017=0.85
					0.0018=0.9
					0.0019=0.95
					0.0020=1.0
					0.0021=1.0

[1] Geerlig's table for dry substance in sugar house products by Abbé refractometer at 28°C.

In using Table 13, find the refractive index which is next lower than the reading actually obtained and note the corresponding whole number for the per cent of dry substance. Subtract the refractive index obtained from the table from the observed reading; the decimal percentages corresponding to this difference, as given in the column so marked, is added to the whole per cent of solids as first obtained.

Correction must also be made for the temperature if above or below 28° C. The temperature correction is obtained from Table 14. For instance, suppose the refractive index was 1.3750 and that the temperature was 25° C. The per cent of solids as obtained from the

table would be 27.2. The correction for temperature would amount to .14, which would be added to this reading, giving 27.34 as the per cent of solids.

TABLE 14.—*Corrections for Temperature to be Used with Table 13*

Temperature, ° C.	Per cent of solids.					
	10	15	20	25	30	40
	To be subtracted					
20	0.55	0.56	0.57	0.58	0.60	0.62
21	.48	.49	.50	.51	.52	.54
22	.42	.42	.42	.44	.45	.47
23	.34	.35	.36	.37	.38	.39
24	.27	.28	.28	.29	.30	.31
25	.21	.21	.22	.22	.23	.23
26	.13	.14	.14	.15	.15	.16
27	.07	.07	.07	.07	.08	.08
	To be added					
29	0.07	0.07	0.07	0.07	0.08	0.08
30	.13	.14	.14	.14	.15	.15
31	.21	.21	.22	.22	.23	.23
32	.27	.28	.28	.29	.30	.31
33	.34	.35	.36	.37	.38	.39
34	.42	.42	.43	.44	.45	.47
35	.48	.49	.50	.51	.52	.54

Whether or not ketchup should be processed after filling into bottles depends on the conditions under which it is bottled. If the bottled product can be sealed at 180° F. or better a process is not necessary and is an unnecessary expense and waste of time, besides it may injure the color of the product. With the modern type of equipment it is possible to fill the bottles at a temperature which obviates sterilization. Care must be taken that the temperature of the ketchup in the receiving tank feeding the filler does not fall too low. Care must also be avoided in order not to fill the ketchup at too high a temperature as it results in excessive shrinkage of the contents.

For ketchup filled at relatively low temperature a process should

be used. The process necessary will depend upon the temperature at which the ketchup is filled and on the time that may elapse between filling and processing. Sanitary conditions of the factory and equipment are exceedingly important not only in relation to ease of sterilization but also in securing a product of good quality.

In stacking ketchup it is best to stack the bottles upside down. This tends to prevent darkening of the ketchup in the neck of bottle, a condition known as "black neck." It has been our experience that wherever this condition has occurred it is due to leakage of air into the bottles. Stacking bottles in this way undoubtedly keeps the cork of the cap moist and makes the seal more effective.

CHILI SAUCE

Chili sauce is of the same general character as ketchup but is made from peeled and cored tomatoes without removing the seeds, contains more sugar and onions and sometimes is made hotter than ketchup by the use of more cayenne pepper. There is a great variation among different manufacturers with respect to the methods of treating the tomatoes. Usually large to medium sized tomatoes are employed, separated from the small tomatoes which are used for making pulp and ketchup. Some manufacturers of chili sauce place the peeled and cored tomatoes directly into the kettle and mix the other ingredients without any form of breaking. Other manufacturers have various methods of breaking and crushing the tomatoes. Several crushers for this purpose are on the market and other means of breaking, such as meat choppers, meat cutters and apple graters are employed. Some convey the tomatoes from the peeling room to the kettle through a pump which breaks them up more or less.

Because of the nature of the product there is no method available for testing the concentration of chili sauce and determining the point at which the cooking should be stopped. The refractometer may be used as a rough method of controlling the concentration. The percentage of solids as determined from the refractometer reading and Geerlig's table is too low on account of the relatively high percentage of insoluble solids. However, a relation betwen the soluble solids and total solids may be obtained in this way which may be useful in controlling the concentration. The consistency of the product is always regulated by its appearance. The amount of cooking varies among different manufacturers but in general there is a concentration of from 40 to 45 per cent of the volume of the raw tomatoes employed. That is, 100 gallons of peeled and cored tomatoes yield from 40 to 45 gallons of chili sauce.

The amount of onions added to chili sauce is substantially larger than the amount used with ketchup. Some manufacturers use approximately twice as much as the former. Hier[1] suggests 100 pounds of onions when used in the preparation of 100 gallons of chili sauce. Large onions should be used since they are more easily peeled and give less waste than smaller onions. They should be carefully

[1] "The Manufacture of Tomato Products, 1919."

peeled and should be finally chopped in order to safeguard against stopping up the tubes of the filling machine.

The cooking is substantially the same as with ketchup and the same ingredients are used with the exception of garlic which is not employed. Some manufacturers make the product rather mild, while others use substantially twice as much cayenne pepper as with ketchup. The same amount of salt and vinegar are employed with ketchup but substantially more sugar, some manufacturers using one-half more sugar than with ketchup.

Because of its lumpy condition chili sauce affords more difficulty in filling into the bottle than is the case with ketchup. The bottle is also harder to seal. Its wide neck makes it more difficult to make the sealing tight than the smaller neck ketchup bottles, and the black rings in the top of the bottle are more frequent and more conspicuous than is the case with ketchup.

The discussion of the processing given under ketchup (p. 70) is also applicable to chili sauce.

PUBLICATIONS
RESEARCH LABORATORY
NATIONAL CANNERS ASSOCIATION

BULLETINS

*1 Some Safety Measures in Canning Factories
*2 Swells and Springers (Superseded by Circular 6-L)
*3 Tomato Pulp (Superseded by Bulletin 21-L)
*4 Preliminary Bulletin on Canning
*5 The Examination of Evaporated Milk
*6 A cause of Dark Color in Canned Corn
*7 Specific Gravity and Solids in Tomato Pulp (Superseded by Bulletin 21-L)
*8 Exhaust and Vacuum
*9 Processing and Process Devices
*10 Lye Peeling
11 Deterioration in Asparagus
12 Washing Fruits and Vegetables
13 Washing and Cleaning Cans
*14 Bacteriological Examination of Canned Foods
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16-L Heat Penetration in Processing Canned Foods
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18-L Black Discoloration in Canned Corn
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4-L The Effect on Canned Foods of Industrial Wastes in the Water Supply
5-L Processing of Peas
6-L Swells and Springers
7-L Processing of String Beans and Beets
8-L Processing of Corn and Pumpkin

*Out of print.